



AGRICULTURAL RESEARCH INSTITUTE

PUSA







# THE OHIO JOURNAL OF SCIENCE

VOLUME XXXIX — 1939

LAURENCE H. SNYDER, Editor-in-Chief

PUBLISHED AT COLUMBUS, OHIO, BY THE

OHIO STATE UNIVERSITY  
and the  
OHIO ACADEMY OF SCIENCE

# THE OHIO JOURNAL OF SCIENCE

---

## ADMINISTRATIVE BOARD

For Ohio State University

F. C. BLAKE

E. N. TRANSEAU

For Ohio Academy of Science

E. L. RICE

W. H. BUCHER

---

## EDITORIAL STAFF

LAURENCE H. SNIDER..... Editor in Chief

BERNARD S. MEYER..... Business Manager

J. B. PARK.....Agronomy

R. A. KNOUFF.....Anatomy

H. H. M. BOWMAN.....Botany

R. C. BURRELL.....Chemistry

E. LUCY BRAUN.....Ecology

F. C. WAITE.....Embryology

G. D. HUBBARD.....Geography

J. ERNEST CARMAN.....Geology

W. H. SHIDELER.....Paleontology

C. W. JARVIS.....Physics

F. A. HITCHCOCK.....Physiology

J. P. PORTER.....Psychology

E. R. HAYHURST.....Public Health

R. V. BANGHAM.....Zoology

---

## THE OHIO JOURNAL OF SCIENCE

Is published jointly by the Ohio State University and the  
Ohio Academy of Science.

# TABLE OF CONTENTS

## VOLUME XXXIX

### NUMBER 1—JANUARY

	Page
The pH Carbon Dioxide Tension, and the Hemoglobin Percentages of Venous Blood of Various Fresh Water Fishes, <i>Edwin B. Powers, Howard H. Rostorfer and Theresa H. Rostorfer</i>	1
Short Studies on the Histeridae (Coleop.)—No. 2..... <i>Rupert L. Wenzel</i>	10
The Hydrogen-ion Concentration of the Soil in Relation to Flora at Squire Valleevue Farm..... <i>Margaret Elizabeth Hodgman</i>	15
Dissolved Oxygen Profiles at Norris Dam and in the Big Creek Sector of Norris Reservoir (1937), with a Note on the Oxygen Demand of the Water (1938)..... <i>A. H. Wiebe</i>	27
Variation in <i>Moniezia expansa</i> Rudolphi..... <i>Stephen R. Williams</i>	37
Snowfall Maps of Ohio..... <i>Fred A. Carlson</i>	43
Spiders and Insects Found Associated with Sweet Corn, with Notes on the Food and Habits of Some of the Species. III. Hymenoptera, <i>Ray Thomas Everly</i>	48
Spiders and Insects Found Associated with Sweet Corn, with Notes on the Food and Habits of Some Species. IV. Diptera and Hemiptera, <i>Ray Thomas Everly</i>	52
The Digestive System of <i>Macrosiphum solanifolii</i> (Ash.). (Aphidae: Homoptera)..... <i>Clyde F. Smith</i>	57
Book Notices.....	9, 36, 42, 51, 56, 60-66

### NUMBER 2—MARCH

Extraordinary Developments at or Near the Ends of Evolutionary Series. Studies in Determinate Evolution, XI..... <i>The Late John H. Schaffner</i>	67
A Critical Analysis of the Movements of The Shoulder-Joint, <i>Linden F. Edwards</i>	83
An Anomalous Artery in the Kingfisher ( <i>Ceryle alcyon</i> )..... <i>Fred H. Glenny</i>	94
The Origin and Development of the Internal Musculature of the Frog Lung ( <i>Rana pipiens</i> )..... <i>F. A. Waterman</i>	97
Studies of the Genus <i>Empoasca</i> (Homoptera, Cicadellidae). Part VI. Twenty-two New Species of <i>Empoasca</i> from North America, <i>Ralph H. Davidson and Dwight M. DeLong</i>	110
Book Notices.....	82, 96, 109, 118

### NUMBER 3—MAY

Diurnal Activity Rhythms in Fresh-Water Fishes..... <i>Warren P. Spencer</i>	119
The Numerical Status of Some Mammals Throughout Historic Time in the Vicinity of Buckeye Lake, Ohio..... <i>Milton B. Trautman</i>	133
Reports on the Flora of Ohio. I. Notes on the Ohio Violets with Additions to the State Flora..... <i>Frederick O. Grover</i>	144
<i>Argia fumipennis</i> in Ohio..... <i>Mike Wright</i>	155
Protozoan Parasites of the Orthoptera, with Special Reference to Those of Ohio. II. Description of the Protozoan Parasites Recognized in This Study..... <i>Frank M. Semans</i>	157
Book Notices.....	132, 143, 154, 156, 182-184

## NUMBER 4—JULY

Report of the Forty-ninth Annual Meeting of the Ohio Academy of Science,	<i>William H. Alexander, Secretary</i> 187
Presidential Address.....	<i>Claude E. O' Neil</i> 213
Long Time Forecasts of Ohio River Floods.....	<i>E. L. Moseley</i> 220
Additions to the Revised Catalogue of Ohio Vascular Plants, VII,	
<i>John H. Schaffner and Clyde H. Jones</i>	232
The Texananus (Homoptera, Cicadellidae) Species of the Majestus Group with the Description of Four New Species.....	<i>Dwight M. DeLong</i> 235
Book Notices.....	212, 231, 238

---

## NUMBER 5—SEPTEMBER

Studies on Rearing the Opossum ( <i>Didelphys virginiana</i> ).....	<i>G. E. Coghill</i> 239
The Production of Accessory Appendages and Anterior Doubling in Frog Embryos by Centrifugal Force.....	<i>C. S. Thornton and R. E. Ellis</i> 250
The Growth of <i>Stereum gausapatum</i> Fries in Relation to Temperature and Acidity.....	<i>J. Arthur Herrick</i> 254
Some Factors Influencing Zooplankton Distribution in the Hocking River,	
<i>Lynn Hutchison</i>	259
The Effects of Man-Made Modifications on the Fish Fauna in Lost and Gordon Creeks, Ohio, Between 1887-1938.....	<i>Milton B. Trautman</i> 275
Book Notices.....	258, 274, 289-290

---

## NUMBER 6—NOVEMBER

Some Practical Considerations in Testing for Genetic Linkage in Sib Data,	
<i>L. S. Penrose</i>	291
A Granodiorite Stock in the Cascade Mountains of Southwestern Washington,	
<i>W. M. Felts</i>	297
Tillite and Varved Slate Erratics in Northern Richland County, Ohio,	
<i>George W. White</i>	317
Five New Generic Names in the Chalcidoidea (Australia).....	<i>A. A. Girault</i> 324
The Nature of the Evolution of Fundamental Potentialities in the Plant Kingdom.....	<i>John H. Schaffner</i> 327
Index to Volume XXXIX.....	349
Book Notices.....	296, 323, 326, 348

# THE OHIO JOURNAL OF SCIENCE

VOL. XXXIX

JANUARY, 1939

No. 1

## THE pH, CARBON DIOXIDE TENSION, AND THE HEMOGLOBIN PERCENTAGES OF VENOUS BLOOD OF VARIOUS FRESH WATER FISHES

EDWIN B. POWERS, HOWARD H. ROSTORFER  
AND THERESA H. ROSTORFER,

Franz Theodore Stone Laboratory  
and

Department of Zoology, University of Tennessee, Knoxville

The carbon dioxide tension of the water has been shown to be an important environmental factor for fishes (Powers and colleagues, various publications). It has been found that the carbon dioxide tension of the blood of fishes approximates the carbon dioxide tension of the water that bathes their gills. The pH of the venous blood of certain fresh water fishes, under experimental conditions, as determined by the Beckman pH meter glass electrode was fairly constant, pH 6.20 to 7.07 over a wide range of carbon dioxide tensions, approximately .09 to 20 mm. Hg (Powers, Rostorfer, Shipe and Rostorfer, 1938). This is far beyond any carbon dioxide tension range found in natural waters under the most adverse conditions where fish are still able to survive. The pH level of the blood in the species of fishes tested, rock bass (*Ambloplites rupestris*), small mouth bass (*Micropterus dolomieu*), and yellow perch (*Perca flavescens*), in the experiments just cited, is maintained by a modification of the alkali reserve of the blood either up or down.

Following these experiments it was decided to determine the pH of the blood of different species of fishes living under natural conditions.

### METHODS

The methods were outlined by the senior author and the observations were made by the two junior authors. The work was carried on for the most part at the Franz Theodore Stone

Laboratory, Put-in-Bay, Ohio. A few of the observations were made at the Zoology Laboratory, University of Tennessee, Knoxville. Fishes were taken by hook and line or seined and placed in live boxes or running water tanks. The fishes were taken from the live boxes in containers and the pH of the blood determined by means of a Beckman pH meter glass electrode as quickly as possible. In a few cases the pH of the blood was determined immediately after taking the fish with hook and line. Blood was drawn from the exposed conus arteriosus with a 5 cc. Leur syringe. Care was taken to withdraw the blood without subjecting it to a negative pressure. However, this could not always be avoided.

All blood tested was *venous* and not *arterial*.

The pH of a portion of the drawn blood was determined immediately and before coagulation took place. A second portion was centrifuged until a clear serum appeared at the top of the centrifuging tube. No anti-coagulant was used. The unmodified serum was then aerated by means of a fine pointed aspirator and the pH determined as in the whole blood. Due to the small amount of blood and serum and the use of laboratory air for aeration, small errors could not be prevented. However, no corrections have been made in any of the data.

#### DATA AND DISCUSSION

In Table I data are arranged in order of the pH difference between the unaerated and aerated environmental water. According to the formula (—)  $\text{pH} = -ne - n\log\text{PCO}_2$  (Powers, 1927, and Powers and Bond, 1927, 1928), the positive difference is the positive difference between the logarithm of the carbon dioxide partial pressure of the atmosphere and the logarithm of the carbon dioxide tension of the water. The negative difference is the negative difference as stated above. These have not been calculated in this paper since neither the value of  $n$  nor the barometric pressure were determined and, thus, the calculated per cent of an atmosphere of carbon dioxide tension below or above the carbon dioxide partial pressure of the atmosphere would be only a close approximation. Figure 1 is a graphic representation of the data of Table I.

When the data, Table 1, and the graphs, Figure 1, are examined it is found that the pH of the blood of a species of fish is fairly constant. In the carp (*Cyprinus carpio*) the extreme variation of pH is 7.19 to 7.56 or .37 pH units. The small

mouth bass has a variation of pH 6.89 to 7.55 or .66 pH units. The perch shows a pH difference of 6.90 to 7.47 or .57 pH units. The pH difference in the blood of the rock bass is 7.02 to 7.75 or .73 pH units. In Table II where data of all fish tested are given the extreme variation in the pH of the blood are the carp, .66 pH units, the rock bass, 1.04, the perch, .77, the small mouth bass, 1.11, the sheepshead (*Aplodinotus grunniens*), .18, the yellow catfish (*Amieurus natalis*), .47 and the jack salmon (*Stizostedion vitreum*), .12. These with two exceptions, the carp, 1.04 pH units, and the small mouth bass, 1.11 pH units, are well within the extreme difference in pH ( $\text{cH } 2.5 \times 10^7$ ) 6.60 and ( $\text{cH } 3 \times 10^8$ ) 7.52 or .92 pH units of the blood of the scup as given by Barcroft (1934).

The difference in pH units between the pH of the blood and the pH of the aerated serum in each species of fish has a greater extreme range than the pH range in the aerated serum, carp .31, rock bass .74, the perch .31, small mouth bass .54, sheepshead<sup>1</sup> .19, yellow catfish .43, and the jack salmon<sup>1</sup> .04. When averages of pH units differences between the blood and aerated serum are considered, we find the following: carp Table I .92 and Table II .87, rock bass Table I .92 and Table II .90, small mouth bass Table I 1.02 and Table II 1.03, sheepshead .39, yellow catfish .54, and jack salmon .35.

The small mouth bass, the most active fish, shows the greatest difference between aerated serum and venous blood carbon dioxide tensions, *i. e.*, pH units. The carbon dioxide tension differences between aerated serum and venous bloods here indicated by these observations might be more an index of the resistance that the fish exerted against the preparation and the drawing of blood from the conus arteriosus and not the true picture of the blood under normal conditions. Taking all these factors into consideration the pH of the aerated serum is a better index of the pH of arterial blood under normal conditions than any other one factor measured.

The experimental error in the observations, and the fact that venous blood and that usually of a struggling fish was tested, would account for the wide variations in the pH of the venous blood of a given species. It is the opinion of the authors that with more refined technique the variation in the pH of arterial blood of fishes will be found to be far less than indicated by the

---

<sup>1</sup>Only three sheepshead and two jack salmon were tested. Thus the data on these two species of fishes are not significant.



TABLE I

DATA ARRANGED IN ORDER OF THE PH DIFFERENCE BETWEEN THE WATER AND THE AERATED WATER FROM WHICH EACH FISH WAS TAKEN

O <sub>2</sub> ml. per L.	pH of Water	pH of Aerated Water	Difference pH Water and Aerated Water	pH of Blood	pH of Aerated Serum	Difference pH Blood and Aerated Serum	Per cent Hemo- globin
CARP							
8.22	8.35	8.45	.10	7.19	7.95	.77	72
8.22	8.35	8.45	.10	7.35	8.28	.93	42
8.22	8.35	8.45	.10	7.56	8.48	.92	47
6.49	8.60	8.50	-.10	7.22	8.24	1.02	35
10.15	8.92	8.81	-.11	7.32	8.35	1.03	...
7.08	8.80	8.67	-.17	7.35	8.26	.91	52
8.64	8.65	8.35	-.30	7.50	8.37	.87	70
SMALL MOUTH BASS							
5.22	8.62	8.50	-.12	7.15	8.23	1.08	76
5.22	8.62	8.50	-.12	7.18	8.28	1.10	82
5.35	8.58	8.45	-.13	7.30	8.23	.93	80
5.35	8.58	8.45	-.13	7.47	8.56	1.09	70
6.55	8.58	8.45	-.13	7.55	8.43	.88	78
7.09	8.80	8.67	-.17	7.16	8.09	.93	40
7.09	8.80	8.67	-.17	7.18	8.02	.88	65
....	8.97	8.80	-.17	7.32	8.52	1.20	68
....	8.97	8.80	-.17	7.33	8.52	1.19	60
....	8.97	8.80	-.17	7.52	8.55	1.03	60
8.64	8.65	8.36	-.31	6.89	7.80	.91	46
PERCH							
7.28	8.30	8.48	.18	6.90	7.80	.90	...
7.33	8.41	8.50	.09	7.20	8.14	.94	30
6.99	8.28	8.20	-.08	7.03	7.99	.96	30
6.99	8.28	8.20	-.08	7.18	8.11	.93	30
6.49	8.60	8.50	-.10	7.47	8.35	.88	...
7.13	8.50	8.37	-.13	7.15	7.95	.80	...
7.13	8.50	8.37	-.13	7.00	8.08	1.08	...
7.65	8.83	8.68	-.15	7.25	8.02	.77	34
ROCK BASS							
8.47	8.00	8.42	.42	7.64	8.50	.86	48
8.47	8.00	8.42	.42	7.68	8.37	.69	50
7.28	8.30	8.48	.18	7.05	7.90	.85	42
7.28	8.30	8.48	.18	7.15	7.72	.57	47
7.33	8.41	8.50	.09	7.18	8.00	.82	49
7.33	8.41	8.50	.09	7.15	8.15	1.00	46
6.35	8.54	8.54	.00	7.35	8.25	.90	46
6.35	8.54	8.54	.00	7.72	8.52	.80	46
6.35	8.54	8.54	.00	7.08	8.30	1.22	50
6.35	8.54	8.54	.00	7.35	8.30	.95	41
6.38	8.55	8.48	-.07	7.32	8.35	1.03	46
7.34	8.62	8.52	-.10	7.50	8.47	.97	45
7.34	8.62	8.52	-.10	7.75	8.45	.70	44
7.34	8.62	8.52	-.10	7.20	8.25	1.05	45
7.34	8.62	8.52	-.10	7.30	8.68	1.38	45
5.22	8.62	8.50	-.12	7.02	7.92	.90	42
7.13	8.50	8.37	-.13	7.08	8.32	1.24	44
7.13	8.50	8.37	-.13	7.08	8.08	1.00	52
5.35	8.58	8.45	-.13	7.18	7.90	.72	50
7.66	8.83	8.68	-.15	7.65	8.44	.79	...
....	8.97	8.80	-.17	7.32	8.47	1.15	...
....	8.85	8.65	-.20	7.22	8.25	1.03	49
....	8.83	8.62	-.21	7.05	7.80	.75	52

data given in this paper. This is borne out by the fact just given that the pH range of aerated serum is less than the

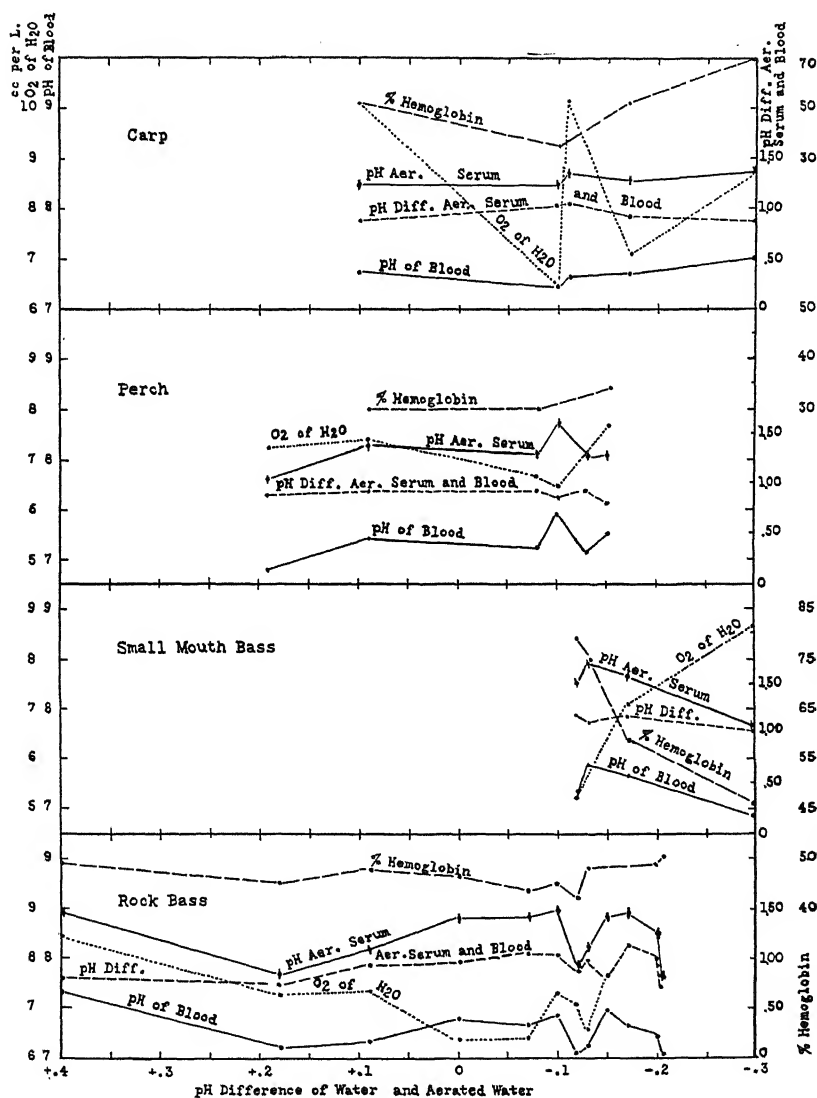


Fig. 1. A graphic representation of the data in Table I.

difference between the pH of the venous blood and aerated serum. By referring to the two tables it is seen that all pH readings of aerated serum are without exception well on the alk-

TABLE II

DATA ARRANGED IN ORDER OF THE PH OF THE BLOOD OF EACH SPECIES OF FISH

pH of Blood	pH of Aerated Serum	Difference pH Blood and Aerated Serum	pH of Blood	pH of Aerated Serum	Difference pH Blood and Aerated Serum
CARP			PERCH		
6.90	7.75	.85	6.70	7.50	.80
6.92	7.76	.84	6.76	7.66	.90
6.96	7.72	.76	6.80	7.74	.94
6.97	7.69	.72	6.90	7.80	.90
7.03	7.83	.80	7.00	8.08	1.08
7.08	8.06	.98	7.03	7.99	.96
7.19	7.95	.77	7.15	7.95	.80
7.22	8.24	1.02	7.18	8.11	.93
7.32	8.35	1.03	7.20	8.14	.93
7.34	8.19	.84	7.25	8.02	.77
7.35	8.27	.92	7.47	8.35	.88
7.50	8.37	.87	SMALL MOUTH BASS		
7.56	8.48	.92	6.44	7.56	1.09
ROCK BASS			6.60	7.80	1.20
6.71	7.80	1.09	6.89	7.80	.91
6.82	7.46	.64	7.00	7.68	.68
6.85	7.85	1.00	7.15	8.23	1.08
6.89	7.93	1.04	7.16	8.09	.93
6.92	7.48	.56	7.18	8.40	1.22
7.02	7.92	.90	7.30	8.23	.93
7.04	7.75	.71	7.32	8.52	1.20
7.05	7.90	.85	7.33	8.52	1.19
7.05	7.80	.75	7.47	8.56	1.09
7.08	8.08	1.00	7.52	8.55	1.03
7.08	8.30	1.22	7.55	8.43	.88
7.08	8.32	1.24	SHEEPSHEAD		
7.15	8.15	1.00	7.16	7.80	.50
7.15	7.72	.57	7.22	7.82	.36
7.18	7.90	.72	7.34	7.83	.31
7.18	8.00	.82	CATFISH		
7.20	8.25	1.05	6.63	7.46	.83
7.22	8.25	1.03	6.72	7.12	.40
7.30	8.68	1.38	7.03	7.49	.46
7.32	8.35	1.03	7.10	7.55	.45
7.32	8.47	1.15	JACK SALMON		
7.35	8.25	.90	6.87	7.20	.33
7.35	8.30	.95	6.99	7.36	.37
7.50	8.47	.97			
7.64	8.50	.89			
7.65	8.44	.79			
7.68	8.37	.69			
7.72	8.52	.80			
7.75	8.45	.70			

line side of neutrality. This is in keeping with the findings of the pH of bloods of all species of fishes reported by Root (1931) and Willmer (1934)<sup>2</sup> (calculated) when the blood was equilibrated with a carbon dioxide partial pressure approximating a carbon dioxide tension found in natural waters where fishes live. Their

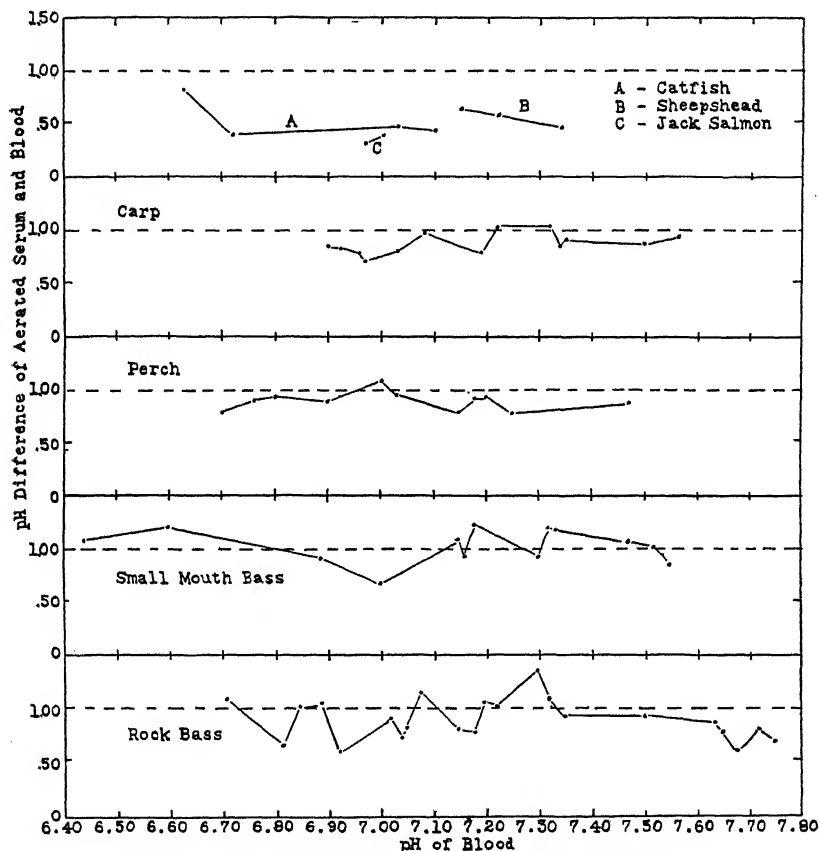


Fig. 2. A graphic representation of the data in Table II.

drawn blood becomes acid only when equilibrated with a carbon dioxide partial pressure in mm. Hg in toad fish of 25.40, in the sea robin of 28.10, in mackerel of 65.05, (Root, 1931), and 25.+ of certain other fishes (Willmer, 1934). These are even higher than the carbon dioxide tension (20.+ mm. Hg) of the experimental water in which fresh water fishes ceased to absorb

<sup>2</sup>The pH given for 0 mm Hg CO<sub>2</sub> is questionable. The method of obtaining the pH's is not clear.

oxygen efficiently (Powers, Rostorfer, Shipe and Rostorfer, 1938). The blood of any fish would never come in contact with carbon dioxide tensions of as high values as given above under normal conditions except in the rete mirabile and the gas glands of deep water fishes.

When we go back and re-examine the data obtained by Powers, Rostorfer, Shipe and Rostorfer (1938) it is found that the pH of the blood of an experimental fish was almost without exception on the acid side of neutrality. The pH difference between blood and aerated serum showed excellent expected correlation with the carbon dioxide tension of the experimental water. In these experiments just cited neither the pH of the venous nor the pH of the aerated serum represent the true or actual pH of arterial blood. This is true of the aerated serum since the carbon dioxide partial pressure (.35% At.) especially was not the same as the carbon dioxide tension (the carbon dioxide tension of the experimental water) in which the arterial blood was in equilibrium. The fishes were suffering from extreme anoxemia and were near death and were not compensating for the accumulation of lactates or lactic acid. The experiments do show a definite cycle in the adjustments of the blood even under adverse conditions.

There are no data on possible seasonal changes in blood reactions.

Both Root (1931) and Willmer (1934) as well as Powers and Hickman (1932) have shown that when fish blood is exposed to higher carbon dioxide tensions the hemoglobin rapidly loses in capacity to combine with oxygen. This is a physiological mechanism which offers strong evidence in support of the theory of deposition of gases into the swim bladder of fishes with rete mirabile gas gland mechanisms (Powers, 1932). It now only remains to be shown whether or not this loss of combining power of hemoglobin at high carbon dioxide tensions is reversible to determine the efficiency of the mechanism of deposition of gases into the swim bladders of the fish.

#### HEMOGLOBIN

The hemoglobin content of the blood was determined with the Dare Hemoglobinometer. The data in Table I are the per cents of hemoglobin when 100% represents 16 grams per 100 cc. of blood which is taken as normal for human blood. Here we have only slight variations from the average of a

species and of all species observed. Again this indicates that a fish has a well adjusted blood system.

### CONCLUSIONS

From these observations it is concluded that under varied but natural conditions the pH of the blood of a species of fish is fairly constant and that this uniformity of the blood including the hemoglobin content is maintained by mechanisms similar to those of higher animals.

### BIBLIOGRAPHY

- Barcroft, J.** 1934. Features in the architecture of physiological function. Cambridge.
- Powers, E. B.** 1927. A simple colorimetric method for field determinations of the carbon dioxide tension and free carbon dioxide, bicarbonates and carbonates in solution in natural waters. I. A theoretical discussion. *Ecology*, 8: 333-338.
1932. The relation of respiration of fishes to environment. X. Mechanism of the deposition of gases into the swim-bladder. *Ecol. Monog.*, 2: 443-465.
- Powers, E. B., and J. D. Bond.** 1927. A simple colorimetric method for field determinations of the carbon dioxide tension and free carbon dioxide, bicarbonates and carbonates in solution in natural waters. II. A critical mathematical analysis of theory and data. *Ecology*, 8: 471-479.
1928. Further notes on the colorimetric method for field determinations of the carbon dioxide tension of natural waters. *Ecology*, 9: 364-366.
- Powers, E. B. and T. A. Hickman.** 1932. The relation of respiration of fishes to environment. VI. Oxygen and carbon dioxide dissociation curves of whole blood. *Ecol. Monog.*, 2: 421-430.
- Powers, E. B., H. H. Rostorfer, L. M. Shipe and T. H. Rostorfer.** 1938. The relation of respiration of fishes to environment. XII. Carbon dioxide as a factor in various physiological respiratory responses in certain fresh water fishes. *Jour. Tenn. Acad. Sci.*, 13.
- Root, R. W.** 1931. The respiratory function of the blood of marine fishes. *Biol. Bull.*, 61: 427-456.
- Willmer, E. N.** 1934. Some observations on the respiration of certain tropical fresh water fishes. *Jour. Expt. Biol.*, 11: 283-306.

---

### A Revision of a Text on General Physiology

One of the earliest text-books in the field of General Physiology was the excellent book of Dr. Philip H. Mitchell published originally some fifteen years ago. The present volume is the third edition of this text. It has been thoroughly revised and somewhat enlarged. In particular the sections on the structure and permeability of cell membranes, physiological oxidation, the chemistry of muscular contraction, vitamins, and the hormones have been revised in the light of recent investigations. A considerable amount of material contained in the book would be found treated in substantially the same way in any standard text on human or mammalian physiology. However, this can scarcely be considered a fault, since there is little agreement among physiologists themselves as to the limits of the field of general physiology. Dr. Mitchell has succeeded in giving in an understandable way much of the physio-chemical background of physiology, which the more conventional textbooks neglect, and in that sense the book is truly a text on General Physiology.—*Fred A. Hitchcock.*

**General Physiology, 3rd edition**, by Philip H. Mitchell. xviii + 853 pp. New York, The McGraw-Hill Book Co., 1938. \$6.00.

## SHORT STUDIES ON THE HISTERIDAE (COLEOP.)—No. 2

RUPERT L. WENZEL,

University of Chicago,  
Chicago, Ill.

To a worker on the North American *Histeridae* it is apparent that a great many of the described species are not valid. Although only about 450 species are known in the literature, a very conservative estimate of the number of names to be "sunk" would total at least 75. The writer has long recognized a great many of the proposed names to be synonyms, but the work of making the synonymy known is slow because of the inaccessibility (for one reason or another) of type specimens and the difficulty of obtaining the necessary data on this little collected and studied group of beetles. Consequently, all that one can do is to publish notes as the material becomes available for study.

This paper is the result, chiefly, of the study of the *Histeridae* in the collections of the Iowa Insect Survey and of the Blatchley collection. It was originally intended that the latter be examined primarily with the purpose of studying the types. A preliminary survey showed, however, that several published records of Blatchley's were based upon incorrect determinations. Some of the more obvious errors were noted and are here called to the attention of the workers in the field. A more thorough investigation of the material will be made at a later date.

Through the kindness of H. E. Jaques (Iowa Wesleyan College) the author was allowed to study the *Histeridae* in the Iowa Insect Survey reference and survey collections. Acknowledgment is also due Mr. George E. Gould (Purdue University) who made it possible to examine the Blatchley Collection and who extended the writer every possible courtesy.

**Saprinus semistriatus** (Scriba), 1790, p. 72 (= *S. lecontei* Csy. 1916, p. 262).

With its introduction and spread in the United States, *S. semistriatus* has become a nearly cosmopolitan species, it being found, in addition, in Northern Africa, Europe, Asia, and Mexico (*nitidulus* Fabr. *sic.*, Lewis 1882, p. 222). At hand are a number of examples from Iowa, Illinois, Michigan, and Indiana. The specimens upon which Casey based his description of *lecontei* were from Pennsylvania, Virginia, North Carolina, and Louisiana. There is a single specimen labeled as

*lecontei* in the Blatchley collection. For the convenience of cataloguers the complete synonymy of *semistriatus* is listed below.

*S. semistriatus* (Scriba), Journ. f. d. Liebhab. Ent., Frankfort, I, p. 72, 1790.

*semipunctatus* (Payk.), Fauna Suec., I, p. 45, 1798.

*acuminatus* (Fabr.), Supplem. Ent. Syst., p. 37, 1798.

*nitidulus* (Fabr.), Syst. Eleuth., I, p. 85, 1801.

*incrassatus* (Fald.), in Ménetriés Cat. Rais. Zool. Caucase, p. 170, 1832.

*krynickyi* (Fald.), Bull. Soc. Imp. Nat. Moscou, V, p. 113, 1832.

*turcomanicus* (Ménetr.), Mem. Ac. Imp. Sci. St. Petersburg., VIII (6), p. 55, 1848.

*subattenuatus* Motsch., Bull. Soc. Imp. Nat. Moscou, XXII (3), p. 95, 1849.

*planusculus* Motsch. *ibidem*, p. 97.

*sparsipunctatus* Motsch. *ibidem*, p. 97.

*uralensis* Motsch. *ibidem*, p. 98.

*punctostriatus* Mars., Ann. Soc. Ent. Fr., II (4), p. 460, pl. 12, fig. 20, 1862.

*steppensis* Mars. *ibidem*, p. 460.

*rugipennis* Hockh., Bull. Soc. Imp. Nat. Moscou, XLV, p. 225, 1872.

*hockhutki* Reitt., Cat. Col. Eur., II, p. 267, 1906.

*subnitescens* Bickh., Ent. Blätter, V, p. 221, 1909.

*lecontei* Csy., Mem. Coleop., VII, p. 262, 1916.

*pacoviensis* Roubal, Acta Soc. Ent. Cech., XXIII, p. 94, 1927.

### **Saprinus imperfectus** LeC.

The specimens labeled as this species in the Blatchley collection, and upon which the record in the *Coleoptera of Indiana* was evidently based, are not *imperfectus* but *S. semistriatus*.

**Saprinus assimilis** (Payk.), 1811, p. 63 (= *S. simulatus* Blatch., 1910, p. 621).

In an earlier paper (1935) the writer pointed out that specimens of *assimilis* with an uninterrupted pygidial sulcus were females and that those with the interrupted sulcus were males. Since that time several thousand specimens have been carefully checked and a few female specimens with an interrupted sulcus were found. This variation is to be expected. Some specimens were also found in which the sulcus was entirely absent. The type of *simulatus* is such form.

**Saprinus conformis** LeC., 1845, p. 72 (= *S. oviformis* Blatch., 1910, p. 622).

In his key Blatchley separates *oviformis* from allied species on the basis of the sutural stria being interrupted basally and apically on his type; the latter does not, however, fit his description. To be sure, it is not quite as well impressed as usual, but this can hardly be used as a diagnostic character, since it occurs rather frequently in populations of *conformis*. Moreover, the comparison of *oviformis* with *S. wacoensis* is unwarranted. The Indiana specimens labeled *S. conformis* in the Blatchley collection were *S. assimilis*.



**Saprinus (Hypocaccus) sphaeroides** LeC., 1845, p. 77 (= *S. impunctellus* Csy., 1893, p. 571; *S. lakensis* Blatch., 1910, p. 623; *S. illinoensis* Wolc., 1912, p. 161; *S. eriensis* Hatch, 1929, p. 82; *S. ontarioensis* Hatch, *ibidem*, p. 82; *S. ohioensis* Hatch, *ibidem*, p. 82; *S. michiganensis* Hatch, *ibidem*, p. 83.)

*S. sphaeroides* is one of the most variable of our *Saprininae*. It ranges (1) in length, from 2–4.5 mm.; (2) in color, from bright aenous to deep bluish-black; (3) in pronotal punctuation, from having a broadly triangular, smooth, discal space to punctate throughout; (4) in elytral punctuation, from absolutely impunctate to punctate in a rather broad apical area, the punctures occasionally entering the intervals between the striae. The spinules of the anterior tibiae also vary greatly, being sometimes almost absent. After examining several thousands of specimens, I am convinced that the forms described as *lakensis*, *impunctellus*, and *illinoensis* are not deserving of even subspecific ranking. At hand are paratypes (Iowa Coll.) of *eriensis* and *ohioensis* and specimens determined by Hatch as his *ontarioensis*. It is difficult to understand why these names were ever proposed. Undoubtedly several other names need yet to be placed as synonyms of *sphaeroides*.

#### **Saprinus (H.) seminitens** LeC.

The specimens labeled *seminitens* in the Blatchley collection should be assigned to *S. sphaeroides* LeC.

#### **Hister laevipes** Germ.

Of a series of seven specimens labeled as this species in the Blatchley collection, only two were correctly determined (Sarasota, Fla.—I/30 & II/13, 1911). The remainder of the series are *H. abbreviatus* (Royal Palm, Fla.—XII/11 & 17, 1924; IV/3, 1925).

**Hister stygicus** LeC., 1845, p. 48 (= *H. jaquesi* Hatch, 1929, p. 76).

Two specimens determined by Hatch as his *jaquesi* are in the Iowa Survey Collection. The differences upon which the species was separated from *stygicus* do not exist. Apparently the latter species was before unknown to Hatch.

**Hister interruptus** Beauv., 1805, p. 180 (= *H. immunis* Er., 1834, p. 143; *H. albertensis* Hatch, 1926, p. 275; *H. carri* Hatch, *ibidem*, p. 276).

The "aberrations" *immunis*, *albertensis*, and *carri* are not, in the writer's opinion, deserving of subspecific ranking. These variants are found wherever one collects a sufficiently large series of specimens. At hand are several extremes in which the fifth stria is complete and arching toward the scutellum but not joining the sutural, which is abbreviated at the basal fifth.

#### **Hister marginicollis** LeC.

In a previous paper (1936) the writer questioned Blatchley's Indiana record (1910) of this species because of the descriptive terms he employed, and suggested that he may have had *H. cognatus* LeC. instead. In the Blatchley collection the series labeled *H. marginicollis* contains two examples of *cognatus*. The rest of the specimens are correctly determined. It is very probable that the discrepancy in the

description referred to was due to the fact that Blatchley obviously confused the two species and possibly based his work at least partially, on the mis-identified material.

**Hister osculatus** Blatch., 1910, p. 607 (= *H. puncticollis* Schffr., 1912, p. 26).

The basal portion of the internal subhumeral stria mentioned by Schaeffer in his description of *puncticollis* is in reality a short external subhumeral which varies in distinctness, being at times entirely absent as in Blatchley's type of *osculatus*. In one example in the series before me, the anterior tibiae are broadly arcuate with only a remote indication of serrulation on the outer edge. In the remaining examples the anterior tibiae are distinctly tridentate. The specimens in the writer's collection were taken in fungus by Dr. C. H. Seevers (Hot Spgs., Ark.—VII/2/35). *H. osculatus* should properly be placed in the Subgenus *Paralister* despite the disposition of its subhumeral striae which recall the condition existing in *H. abbreviatus*.

### **Hister grandis** n. sp.

Form broad, oblong-subparallel, moderately convex; color black, shining. Head nearly one-half as broad as pronotum, distinctly punctulate; frontal striae distinct, rather feebly, inwardly angulate at middle; a fine marginal stria present along posterior margin of head.

Pronotum nearly one-half as long as broad, sides nearly parallel on basal half, anteriorly strongly arcuate and convergent. Marginal striae fine, broadly interrupted behind the head; the single lateral pronotal stria deeply impressed laterally and extending nearly to the base of the pronotum, the stria continuing around the anterior angles and complete, though finely impressed, behind the head. Disc of pronotum sparsely, indistinctly punctulate; within the lateral pronotal stria there is on each side a rather broad area of sparse, coarse punctures.

Marginal elytral stria absent. Epipleural fossa with two indistinct, nearly confluent striae. External subhumeral stria represented by a short arc on the humeri; internal subhumeral represented by a few poorly impressed, somewhat disconnected punctures on apical half. Dorsal striae one to four complete, well impressed, crenately punctate, though not strongly so; fifth dorsal and sutural extending from middle to apex, the sutural broken up into coarse punctures at the apex.

Propygidium sparsely, moderately coarsely punctate (punctures separated for the most part by one to three times their diameters), the punctures along the base coarser; very fine, sparse punctures intermingled throughout. Pygidium similarly, but a little more finely punctate, the punctures becoming minute and very sparse at apex.

Prosternum sparsely punctulate; prosternal lobe truncate at apex, sparsely punctulate medially, more coarsely so laterally; apical margin of lobe without a stria, sides strongly margined.

Meso- and metasterna sparsely, minutely punctate. Mesosternum distinctly emarginate along anterior edge, its marginal stria well impressed, not continuous with the marginal metasternal stria which extends medially for a short distance along the meso-metasternal suture.

Anterior tibiae with three distinct teeth and evidence of a fourth;

anterior tooth feebly bifid. Outer margins of the middle and posterior tibiae biserially spinulose.

Length (from anterior angles of pron. to apex of pygidium): 7.15 mm. Width (at humeri): 4.96 mm.

*Type*: a unique male, collected by C. Horn, Henry County, Iowa, March 24, 1936. The type, at present in the Iowa Survey Collection, is to be deposited in the United States National Museum.

This new species resembles *osculatus* in the punctuation of the pronotum but may be readily distinguished from it by the following differences:

*H. osculatus*

*H. grandis*

- |   |   |
|---|---|
| 1. Form broadly oval.   | 1. Form broadly oblong-subparallel.   |
| 2. Marginal pronotal stria complete behind the head and well impressed. | 2. Marginal pronotal stria broadly interrupted behind the head.                               |
| 3. Lateral pronotal stria abbreviated near the anterior angles.         | 3. Lateral pronotal stria continuous around the anterior angles and complete behind the head. |
| 4. Marginal elytral stria present and well impressed.                   | 4. Marginal elytral stria absent.   |
| 5. Marginal stria of head absent.                                       | 5. Marginal stria of head present along posterior margin.                                     |

LITERATURE CITED

- Beauvois, Palisot de. 1805. Insectes recueillis en Afrique et en Amérique. Paris, 1-276.
- Blatchley, Willis S. 1910. An illustrated descriptive catalogue of the Coleoptera or beetles known to occur in Indiana. Bull. Ind. Dept. Geol. & Nat. Res., I.
- Casey, Thomas L. 1893. Coleopterological Notices. Ann. N. Y. Acad. Sci., VII: 281-606.
1916. Some random studies among the Clavicornia. Mem. Col., VII: 35-292.
- Erichson, Wilhelm. 1834. Uebersicht der Histeroides der Sammlung. Klug's Jahrbücher der Insektenkunde: 83-205.
- Hatch, Melville. 1926. New and noteworthy Histeridae from Alberta. Canad. Ent., LVIII: 272-276.
1929. Studies on the Histeridae. Canad. Ent., LXI: 76-84.
- LeConte, John E. 1845. Monograph N. Am. Histeroides. Bost. Journ. N. H., V: 32-86.
- Lewis, George. 1888. Histeridae. Biol. Centrali-Amer. Insecta, II. Pt. 1: 182-244.
- Paykull, Gust. von. 1811. Monographia Histeroidum. Upsala.
- Say, Thomas. 1825. Descriptions of new species of *Hister* and *Hololepta* inhabiting the United States. Journ. Ac. N. S. Phila., V: 32-47.
- Schaeffer, Charles. 1912. Three new species of *Hister*. Bull. Brook. Ent. Soc., VIII: 26-27.
- Scriba, Ludwig. 1790. Verzeichniss der Insekten in der Darmstädter Gegend. Journ. f. d. Liebhaber der Entomologie, I: 40-73, 151-192, 275-296.
- Wenzel, Rupert L. 1935. Notes on the sexual characters of *Saprinus* with the description of a new species. Canad. Ent., LXVII: 189-190.
1936. Short Studies in the Histeridae—No. 1. Canad. Ent., LXVIII: 266-272.
- Wolcott, A. B. 1912. Two new species of Coleoptera from Illinois. Canad. Ent., XLIV: 161-163.

# THE HYDROGEN-ION CONCENTRATION OF THE SOIL IN RELATION TO FLORA AT SQUIRE VALLEEVUE FARM

MARGARET ELIZABETH HODGMAN,

Western Reserve University

The intensive study of the relation of the hydrogen-ion concentration of the soil to plant growth has developed mainly within the last twenty years. Gillespie (7) was the first to use the hydrogen electrode on an extended scale as an indicator of reaction in soils. The use of this method, which is now generally accepted as indicating soil acidity or alkalinity, has been based on the assumption that the only direct explanation of soil acidity is the presence of the hydrogen-ion.

Much of the work on soil reaction has been carried out in cultivated soils. Weir (17) presents a table on soil reaction in relation to growth of economic plants. However, there have also been many papers dealing with the acidity and alkalinity of natural soils. Salisbury (13) points out that the hydrogen-ion concentration varies not only with the degree of leaching and organic content but also according to the source of the organic material and the phase of its decomposition. According to Atkins (2) the underlying rock or the rock from which the soil was derived also affects soil acidity.

Wherry (18) was one of the first investigators to study natural plant distribution from the point of view of the hydrogen-ion concentration of the soil. He and two other independent investigators, Arrhenius (1) and Olsen (12), came to very similar conclusions at approximately the same time, describing a surprising correlation between many plant species and hydrogen-ion concentration. Other investigators, notably Salisbury (13), Kelley (8), Kurz (10) and Cain (3), have also found a high correlation between pH and distribution of many flowering plants. The viewpoint that it is the sole factor in plant distribution has practically disappeared. Geisler (6) has pointed out that many herbaceous flowering plants of the forests tolerate a wide pH range. Coile (4) concluded that soil reaction was probably an unimportant factor in the distribution of seven forest types with which he worked. On the other hand, Shear and Stewart (14) stated that certain species of trees were found to have a fairly characteristic pH.

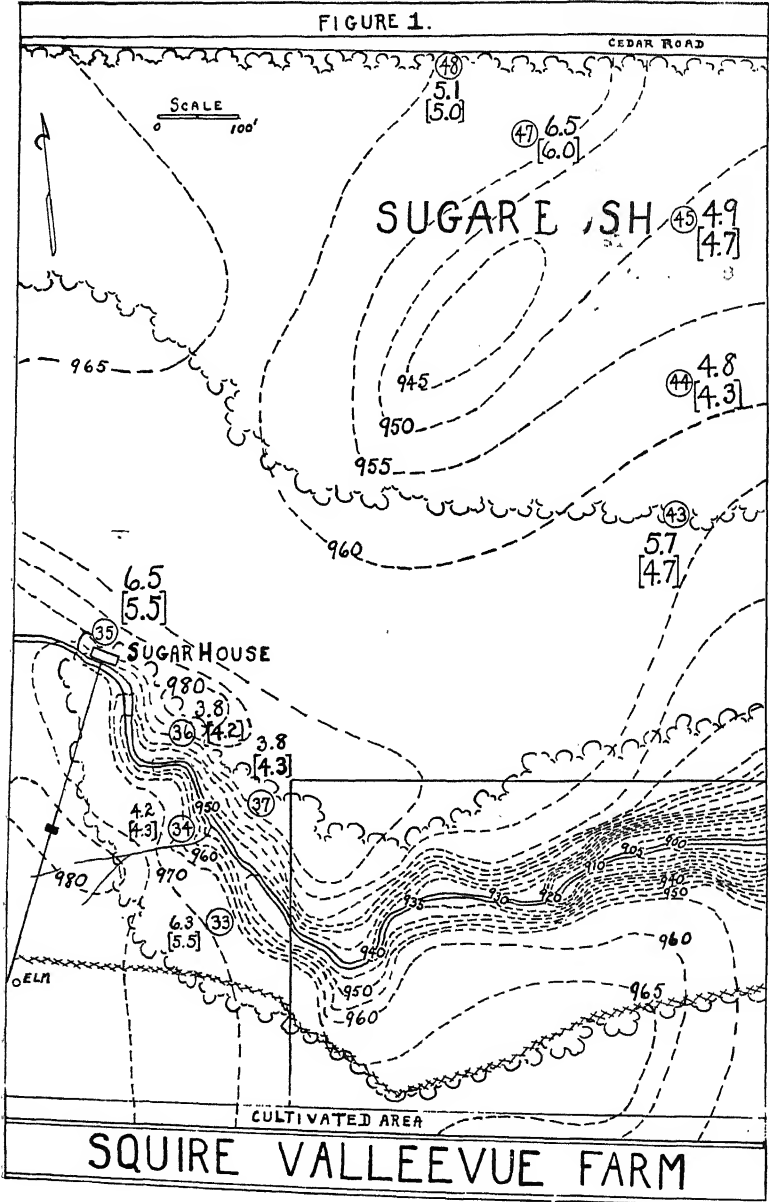


Fig. 1. General topography of Squire Valleevue Farm.

Waksman (15) was among the first to realize the significance of soil fungi in relation to soil reaction and growth of higher plants. Coleman (5) states that fungi occur in large numbers in soil rich in humus and of a high acid reaction. The work of Kopeloff (9), Salisbury (13) and Waksman (16) also indicates that the balance between the number of fungi and bacteria is determined by the reaction of the soil.

While there has been a considerable amount of work done on the separate phases of the problem, there has been very little done on the interrelationships between the reaction of the soil, the microflora and the distribution of higher plants in uncultivated areas. Morrow (11) found that her results supported the idea that the soil reaction and microflora are edaphic factors of consequence in relation to the plant cover and to the character of the soil.

The correlation of soil reaction and plant distribution, including both the microflora and the higher plants, was studied for a given uncultivated area within Squire Valleevue Farm in Cuyahoga County, Ohio. Since this correlation is based on many complex interrelationships it was naturally impossible to consider all of the factors involved so that definite conclusions might be reached. However, the results of this work seem to indicate that there is some correlation between the hydrogen-ion concentration of the soil and natural plant distribution.

There are two main considerations in connection with this general problem. First, it is essential to know the variability of the soil reaction in relation to other edaphic factors. These factors include elevation, drainage, moisture content, organic content, soil type, and soil gradient. Second, it is essential to know the types of plants within this area and their distribution in relation to the soil reaction. The higher plant forms are considered separately from the microflora because of the different methods involved in the study of each.

The area which was investigated is approximately 21 acres in extent and is well wooded. Figure 1 shows the contour lines and the general topography of the area. The underlying bedrock consists of sandstone and shale and the soil is a type of clay loam which is known to be acid and markedly deficient in lime carbonate. The layer of humus overlying the clay loam varies from one to four inches in depth. The soil has never been cultivated as far as it was possible to determine.

In the northern part of the area is an old sugar bush which represents a typical beech-maple climax community. Along

TABLE I  
VARIATION IN SOIL REACTION

Station	Depth in Inches	pH Fresh Soil October	pH Oven-dried 103° C.	pH Fresh Soil April	Percentage Loss on Ignition
1.....	0-1 9-10	4.4 4.6	4.4 4.6	3.9 4.6	66.20 6.60
2.....	0-1 9-10	5.0 4.9	4.8 4.7	4.7 4.5	4.85 .98
3.....	0-1 9-10	4.2 4.5	3.6 4.4	3.7 4.5	67.81 6.50
4.....	0-1 9-10	4.7 4.8	4.3 4.5	4.5 4.6	23.15 8.00
5.....	0-1 9-10	4.4 4.5	4.2 4.5	4.4 4.4	25.13 11.64
6.....	0-1 9-10	5.3 5.8	5.5 5.5	5.2 5.6	6.76 2.99
7.....	0-1 9-10	4.3 4.2	4.1 4.2	4.2 4.3	28.50 5.37
8.....	0-1 9-10	3.7 4.1	3.7 4.2	3.8 4.1	61.87 13.06
9.....	0-1 9-10	4.2 4.5	4.1 4.5	4.2 4.6	83.94 7.46
10.....	0-1 9-10	3.7 4.3	3.7 4.3	4.4 4.5	39.62 1.70
11.....	0-1 9-10	4.5 4.2	4.2 4.1	4.2 4.5	14.99 13.26
12.....	0-1 9-10	4.7 4.4	4.1 4.0	4.7 4.4	11.42 7.64
13.....	0-1 9-10	4.5 4.9	4.2 4.7	5.1 4.9	18.64 2.42
14.....	0-1 9-10	4.6 4.6	.... ....	4.7 4.6	22.01 7.46

the ravine, however, there are many hemlocks and black birches forming primarily a hemlock, beech and birch association.

It was necessary to set up soil sampling stations over the area at random, irrespective of the vegetation in order that the variability of the soil reaction might be analyzed in relation to the topography, depth, and organic content of the soil. Samples were taken at the surface (0-1") and at the subsoil (9-10"). The hydrogen-ion concentration of the soil was determined using a quinhydrone reference electrode. The entire range of pH was from 3.7 to neutral. Practically all of the soil is distinctly acid and the degree of acidity of the soil from sampling stations only a few feet apart may vary more than 0.5 pH.

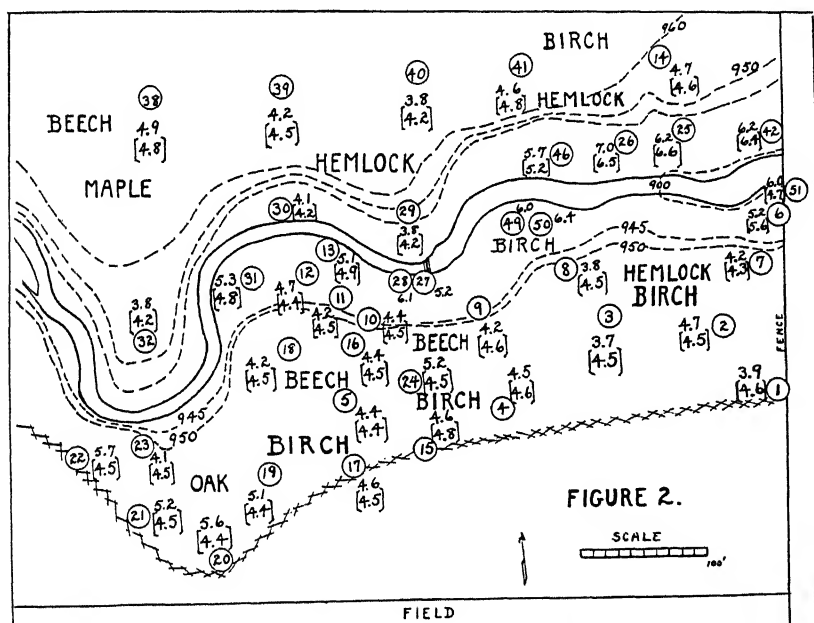


Fig. 2. The pH of the soil in relation to the topographical features of the farm.

However, a certain amount of variability is expected and reasons for large differences in pH may usually be assigned to such factors as organic content, leaching, or plant cover.

Data on the soil from 14 of the sampling stations are shown in Table I. It gives a comparison of the pH of the soil obtained in the fall when it is moist and when it is dried in an oven at 103° C. for at least six hours. The results seem to show that drying soil at high temperatures slightly increases the acidity of the soil, and the change may depend upon the original



pH and type of soil. The table also shows the variations between the fresh soil collected in October and that obtained

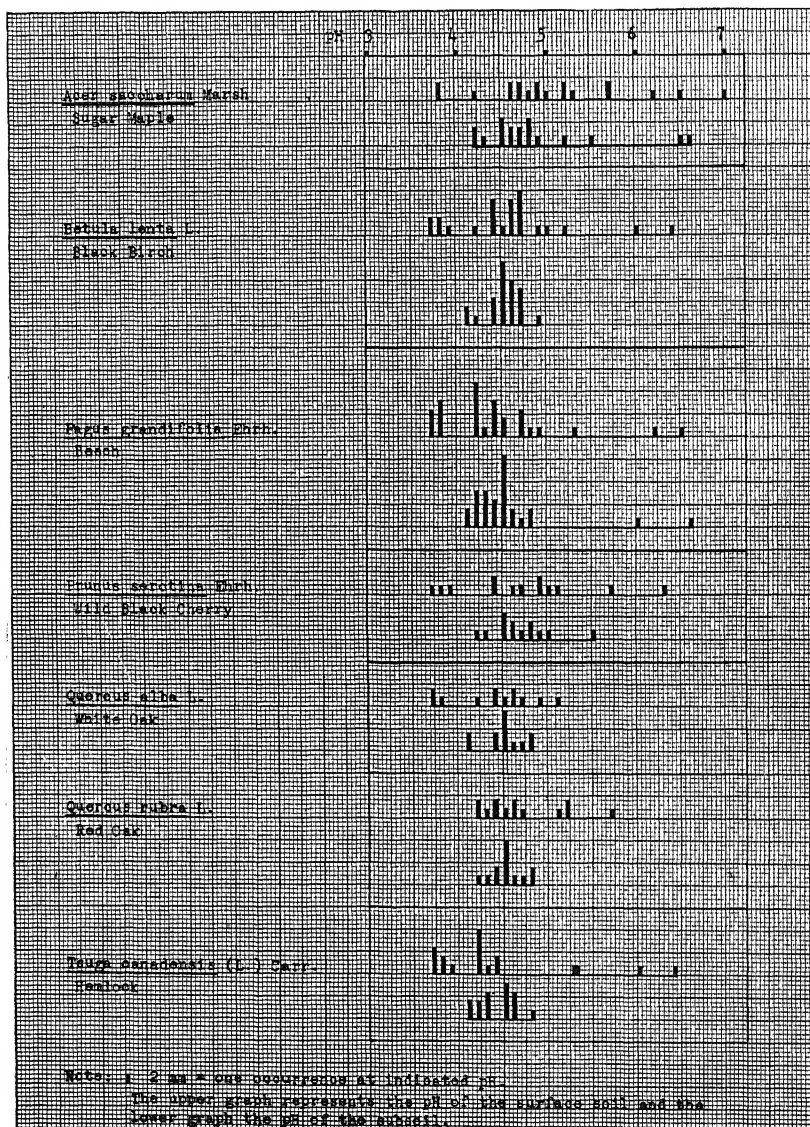


Fig. 3. Frequency distribution and pH range of trees.

in April, but no conclusions could be made from this data to indicate that the hydrogen-ion concentration of the soil might

be definitely greater in one of these seasons. The percentage loss on ignition has been considered as roughly indicating the

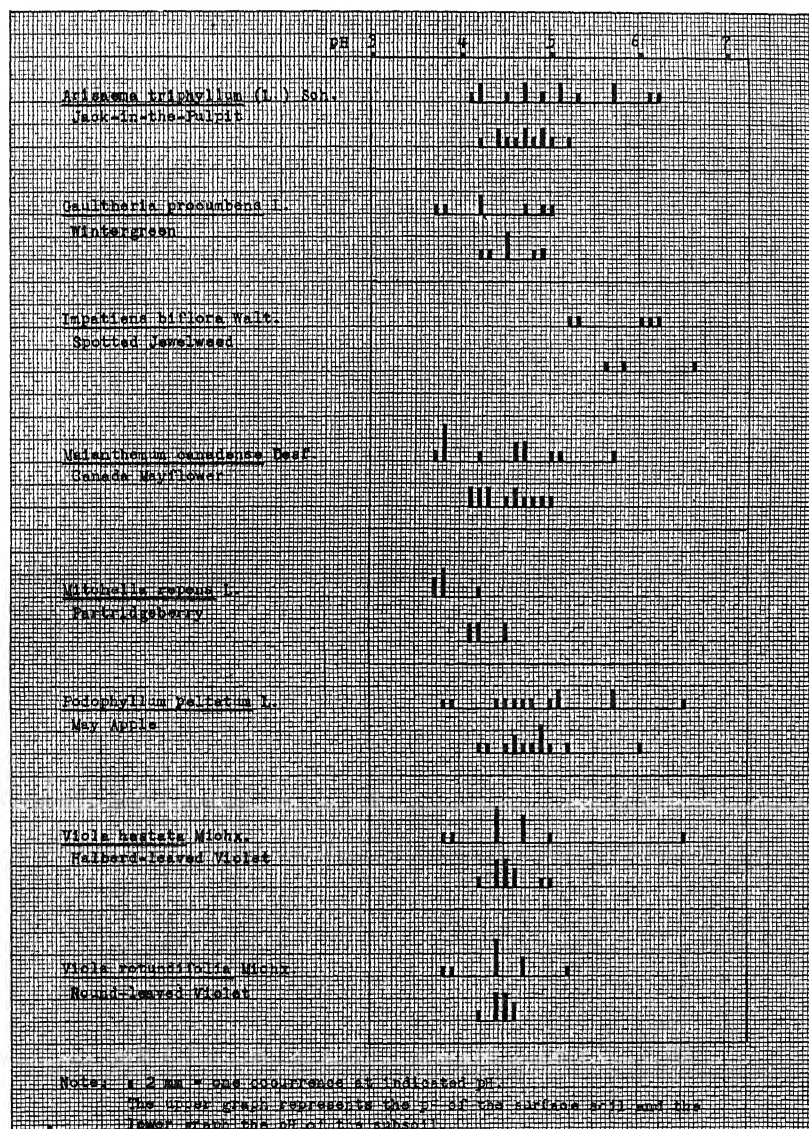


Fig. 4. Frequency distribution and pH range of flowers.

organic content of the soil. The results show a consistently higher percentage of organic matter in the surface soil than in

the subsoil as was expected. While there is no consistent correlation between the percentage of organic matter and the degree of acidity, yet there is evidence that the acidity increases with the organic content of the soil.

The pH of the soil in relation to topographical features and general plant cover is shown in Figure 2. The number of the soil sampling station is indicated in the circle. The map shows the pH of the surface soil at each station and that of the subsoil in parenthesis. First it is evident that the most acid soil is along the upper edge of the ravine. It is most densely wooded in this area and consequently the organic content of the soil is very high. It is possible that leaching may play a role in determining the soil acidity since the acidity tends to decrease with the slope. The plant cover is definitely a factor in determining the soil pH, particularly at the surface. The soil is most acid underneath the hemlocks where needles tend to keep the pH at the surface layer very low. Most of the hemlocks are along the upper edge of the ravine and therefore tend to keep the acidity in this area quite high. Only a few hemlocks are growing at the bottom of the ravine or near the edge of the woods. At Station 1 the lone hemlock apparently lowers the pH of the soil in the immediate vicinity to 3.9. The subsoil under the hemlocks is less acid than the surface soil in all cases. Despite the relatively high organic content of the soil beneath the birch and beech, the surface layer tends to be slightly less acid than the subsoil. This could be explained according to the theory of Salisbury (13) who believes that the complete removal of bases from the surface is retarded because of the high calcium content of the leaves of these trees.

The correlation of soil reaction and plant distribution may be shown by means of graphs that indicate both the pH range and the frequency distribution of most of the trees, shrubs, flowers, ferns and mosses within a few feet of each sampling station. The common species of trees shown in Figure 3 have fairly representative frequency distribution graphs. Such trees as the sugar maple, black birch, beech, black cherry, red oak, white oak and hemlock show a fairly wide pH range with an apparent optimum range in which they are most abundant. The sugar maple, for example, shows a pH range in the surface soil from 3.8 to neutral, with an optimum pH range from 4.6 to 5.7. The black birch shows a range from 3.7 to 6.4 with an optimum range from 4.4 to 4.7. Beech shows a range

from 3.7 to 6.5 with an optimum range from 3.7 to 4.7. The two species of oak show a narrower pH range than some of the other common trees. The hemlock seems to have a fairly wide range of reaction tolerance from 3.7 to 6.4, but was found most commonly in soil which was very acid, from 3.7 to 4.4. The subsoil in each case shows a similar optimum pH range for each tree but the range is narrower than that of the surface soil.

The frequency distribution and pH range of some of the common flowers in the area are shown in Figure 4. On the whole, the flowers that were studied showed less reaction tolerance than the trees. These graphs confirm the general observation that plants such as wintergreen, partridgeberry and Canada Mayflower tend to grow in more acid soil than such plants as jack-in-the-pulpit and spotted jewelweed. Again there is an indication that plants may have a fairly wide pH range and a more limited optimum pH range. For example, the halberd-leaved violet shows a range from 3.8 to 6.5 but it was found more frequently in soil from pH 4.4 to 4.7.

The study of the microflora of the soil in relation to the soil reaction required quite a different technique. The relative abundance of molds and bacteria in relation to soil reaction was determined by the plate method. The results showed that in the general count of microflora within the wooded section immediately south of the ravine the bacteria far outnumbered the molds per gram of soil both at the surface and the subsoil. However, in very acid soil with a pH of 3.8 the molds outnumbered the bacteria at the surface layer. In the subsoil with a pH of 4.1, the number of bacteria per gram of soil exceeded the count of the molds considerably. Edaphic conditions such as moisture content and aeration undoubtedly are other factors in determining the count of microflora.

#### SUMMARY

Variability of the soil reaction apparently depends to a considerable extent on the amount of organic material, the degree of leaching, and the plant cover. The soil was most acid under the hemlocks and least acid under beech and birch. The majority of plants studied showed a fairly wide range, within certain limits, of reaction tolerance. The herbaceous plants appeared to be somewhat more sensitive to soil acidity than the trees as a group. Of the microflora, the molds were more acid tolerant than the bacteria in soils with a pH less

than 4.0. In general the results of the study seem to verify the opinion that while the hydrogen-ion concentration is not the sole factor in plant distribution, it is, at least, one of considerable importance.

#### BIBLIOGRAPHY

- (1) Arrhenius, Olof. "Oecologische Studien in den Stockholmer Schaeren, Stockholm," reviewed in *Ecology*, **2**, 223-228 (1921).
- (2) Atkins, W. R. G. "Some Factors Affecting the Hydrogen-ion Concentration of the Soil and its Relation to Plant Distribution," *Notes Bot. School Trinity College, Dublin*, **3**, 133-177 (1922); *Exp. Sta. Record*, **48**, No. 6, 514-15 (1923).
- (3) Cain, Stanley A. "Ecological Studies of the Vegetation of the Great Smoky Mountains of North Carolina and Tennessee. 1. Soil Reaction and Plant Distribution," *Bot. Gazette*, **91**, 22-41 (1931).
- (4) Colle, T. S. "Soil Reaction and Forest Types in the Duke Forest," *Ecology*, **4**, 323-333 (1924).
- (5) Coleman, David A. "Environmental Factors Influencing the Activity of Soil Fungi," *Soil Science*, **2**, 1-65 (1916).
- (6) Geisler, Sylvia. "Soil Reactions in Relation to Plant Successions in the Cincinnati Region," *Ecology*, **7**, 163-184 (1926).
- (7) Gillespie, L. J. "The Reaction of Soil and Measurements of Hydrogen-ion Concentration," *Jour. Wash. Acad. Sci.*, **6**, 7-16 (1916).
- (8) Kelley, A. P. "Plant Indicators of Soil Types," *Soil Science*, **13**, 411-423 (1922).
- (9) Kopeloff, Nicholas. "The Effect of Soil Reaction on Ammonification by Certain Soil Fungi," *Soil Science*, **1**, 541-573 (1916).
- (10) Kurz, H. "Relation of pH to Plant Distribution in Nature," *Am. Nat.*, **64**, 314-341 (1930).
- (11) Morrow, Marie B. "Correlation between Plant Communities and the Reaction and Microflora of the Soil in South Central Texas," *Ecology*, **12**, 497-507 (1931).
- (12) Olsen, Carsten. "Concentration of Hydrogen-ions in the Soil," *Science*, n. s., **54**, 539-541 (1921).
- (13) Salisbury, E. J. "Stratification and Hydrogen-ion Concentration of the Soil in Relation to Leaching and Plant Succession, with Special Reference to Woodlands," *Jour. Ecol.*, **9**, 220-240 (1922).
- (14) Shear, G. M. and Stewart, W. D. "Moisture and pH Studies of the Soil under Forest Trees," *Ecology*, **15**, 145-153 (1934).
- (15) Waksman, S. A. "Is There Any Fungus Flora of the Soil?" *Soil Science*, **3**, 565-589 (1917).
- (16) Waksman, S. A. *Principles of Soil Microbiology*. Baltimore, The Williams and Wilkins Co., 1932.
- (17) Weir, Wilbert W. *Soil Science, Its Principles and Practice*. Chicago, Lippincott and Co., 1936.
- (18) Wherry, E. T. "Soil Acidity and a Field Method for Its Determination," *Ecology*, **1**, 160-173 (1920).



Fig. 5. View of the ravine section at the waterfall showing the bedrock formation of shale and sandstone. The hemlock in the foreground was the only one found growing in a soil with a pH of 6.0 to 6.4. It was the only hemlock of any size growing at the bottom of the ravine.



# DISSOLVED OXYGEN PROFILES AT NORRIS DAM AND IN THE BIG CREEK SECTOR OF NORRIS RESERVOIR (1937), WITH A NOTE ON THE OXYGEN DEMAND OF THE WATER (1938)<sup>1</sup>

A. H. WIEBE,

Biological Readjustment Division,  
Department of Forestry Relations (T.V.A.)

## INTRODUCTION

A limnological study of Norris Reservoir was begun by the author early in August, 1937. It became apparent immediately that the vertical distribution of dissolved oxygen along with that of some other chemical constituents in the lower and deeper sections of the reservoir was quite different from that usually found in lakes that become stratified during the summer. Thermal stratification, however, occurred in the usual manner. It is the object of this paper to report, briefly, on the vertical distribution of dissolved oxygen (D. O.) in the Big Creek Sector of Norris Reservoir. Originally Big Creek was a tributary of the Clinch River, entering the latter approximately three miles above the present location of Norris Dam. The flooded section of Big Creek is approximately fifteen miles long (depends on elevation of lake surface). The length of the original channel that is flooded by the reservoir would be considerably more than fifteen miles. The approximate depth of the water at the various stations may be obtained from Figures 1-5.

## DATA

The atypical stratification with respect to D.O. was due to the presence of a stratum of water low in D.O. in between two strata of relatively well areated water.

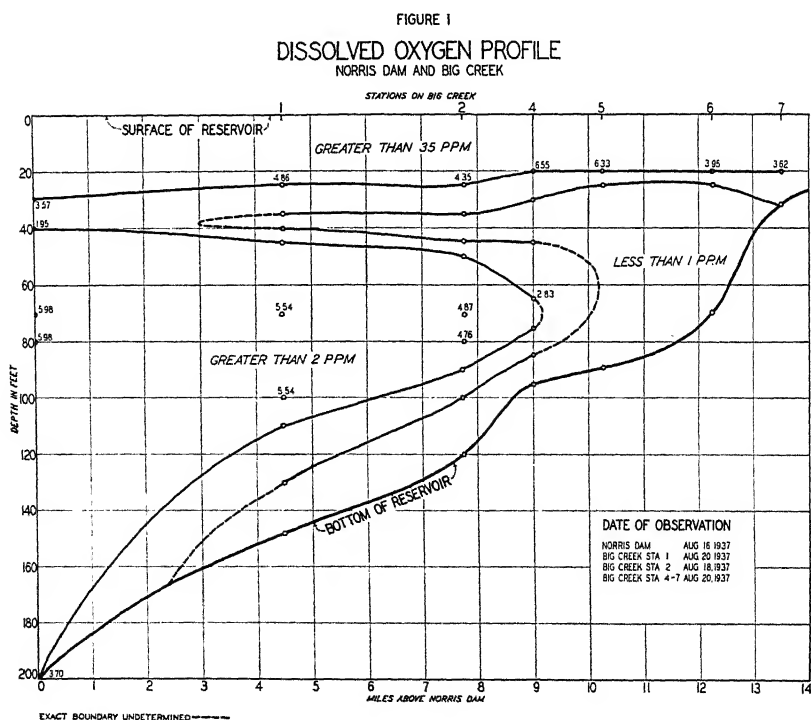
Figures 1-5 illustrate the condition with respect to D.O. at Norris Dam and at six stations on Big Creek. In all charts the values for Norris Dam are at the left margin of the chart; the numerals 1-7 at the top of each chart refer to stations on Big Creek. The numbers on the face of the chart represent values for D.O. in parts per million (p.p.m.). Dates of observation are indicated on the charts.

---

<sup>1</sup>Published by permission of the Tennessee Valley Authority.



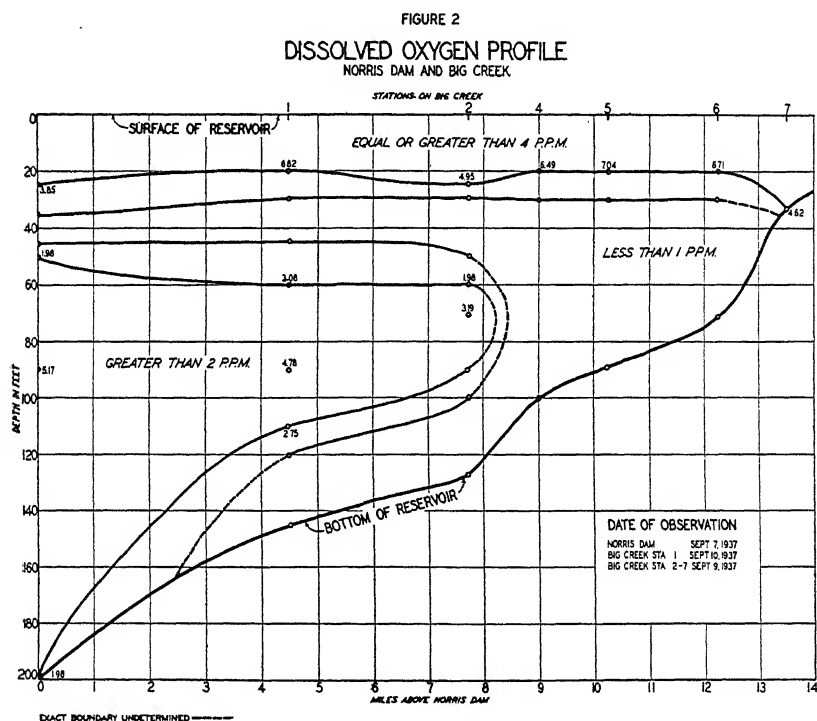
Figure 1 shows the existence of a relatively thin stratum of well aerated water at the surface. This is followed by a still thinner sheet of water in which the D.O. diminishes rapidly. Then follows a layer of stagnant water having less than 1.0 p.p.m. of D.O. At Stations 5 and 6, this stagnant water extends from a depth of 25 ft. to the bottom, thus forming a pool. At Stations 1 and 2 and 4, it is wedge-shaped in a side view and does not extend to the bottom. It should be



noted that the stratum of stagnant water becomes thinner towards the lower end of the reservoir. This decrease in thickness is due to an increase in the cross-section of the reservoir. Between #1 on Big Creek and Norris Dam, the stagnant water (less than 1.0 p.p.m.) disappears completely. This is shown by the presence of 1.95 p.p.m. of D.O. at 40 feet. The chart shows that the stagnant water extends also along the bottom of the reservoir from Station 6 to Station 1 on Big Creek, but at the Dam there are still 3.7 p.p.m. D.O. at the bottom on August 16. The next point of interest in

Figure 1 is the wedge of relatively well aerated water extending from the dam towards the head of the reservoir and reaches #4 on Big Creek. In this wedge the D.O. reaches a maximum of 5.98 p.p.m. at the dam, 5.54 p.p.m., 4.87 p.p.m., and 2.83 p.p.m. at Nos. 1, 2 and 4, respectively. As will be pointed out later, this wedge of well aerated water is a residue from the time when conditions in the reservoir were homogeneous.

The picture presented by Figure 2 is essentially the same as that shown in Figure 1. However, the following changes

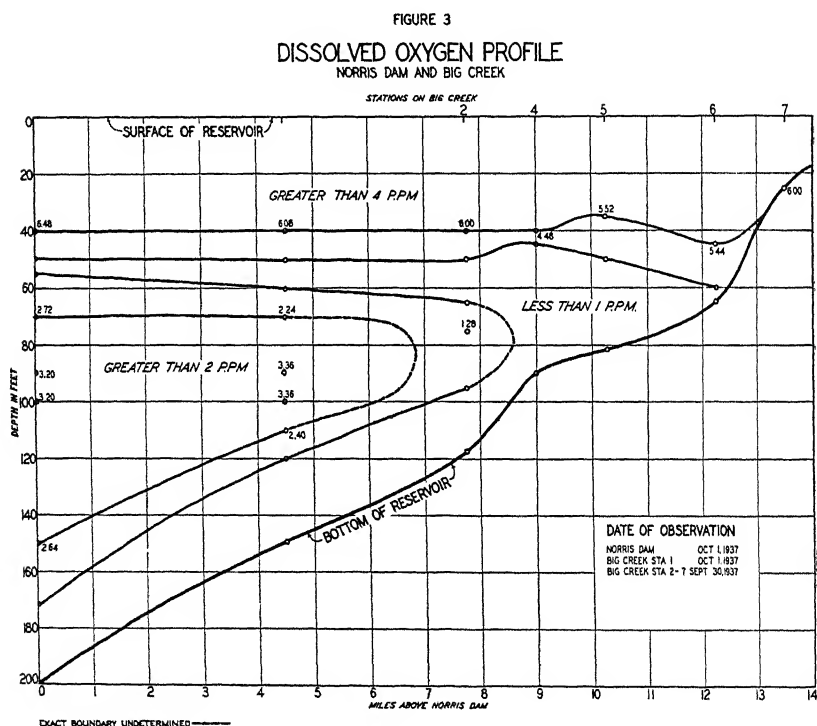


should be noted: (1) the stratum of stagnant water (less than 1.0 p.p.m.) now extends to the Dam at from 35 to 45 feet below the surface; (2) the stagnant water at #4 is no longer divided by the wedge of well aerated water, but is present at all depths below 30 feet; (3) a decrease in the D.O. at the bottom near the Dam, and (4) a reduction in D.O. within the wedge of well-aerated water.

Figure 3 shows the following changes from conditions shown in Figure 2: (1) An increase in thickness of the surface

stratum of well areated water, (2) the resulting lowering of the level of the stagnant water (intrusion sheet), (3) the stagnant water on the bottom extends to the Dam, and (4) a further reduction in D.O. and in thickness of the wedge of well-aerated water.

Figure 4 shows: (1) A further increase in the thickness of the layer of well-aerated surface water, and an additional lowering of the intrusion sheet of stagnant water, and (2) the



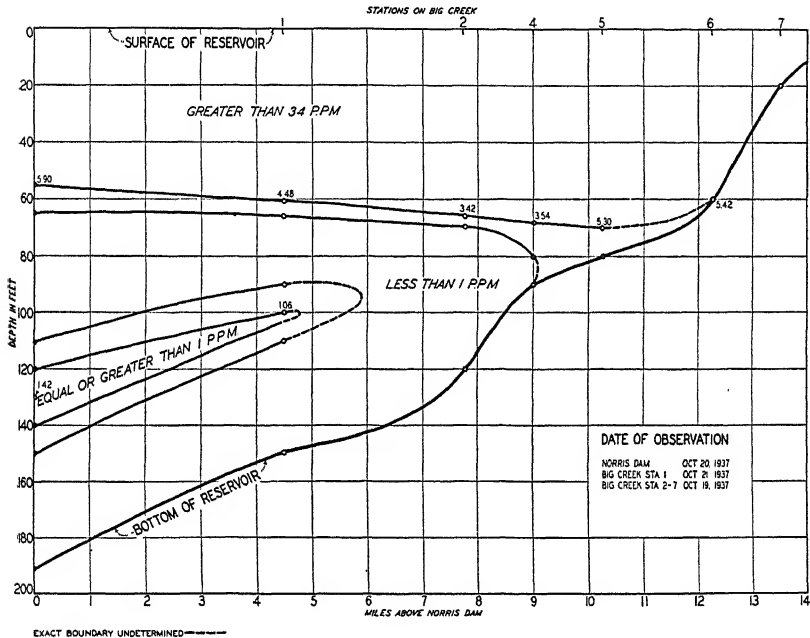
virtual disappearance of the wedge of well-aerated water with the resulting increase of the volume of stagnant water below and above this wedge.

Finally, Figure 5 shows that conditions typical of lakes and reservoirs subject to stratification, namely, a well created epilimnion, a narrow zone of transition (rapid diminution in D.O.) and an oxygen poor hypolimnion.

It may be stated here without further discussion that the changes in the D.O. profiles as pointed out in the discussion

of them are brought about by the following three factors: (1) Continues oxygen demand, (2) withdrawal of water at the dam, and (3) influx of fresh water spread over the surface of the reservoir.

FIGURE 4  
DISSOLVED OXYGEN PROFILE  
NORRIS DAM AND BIG CREEK



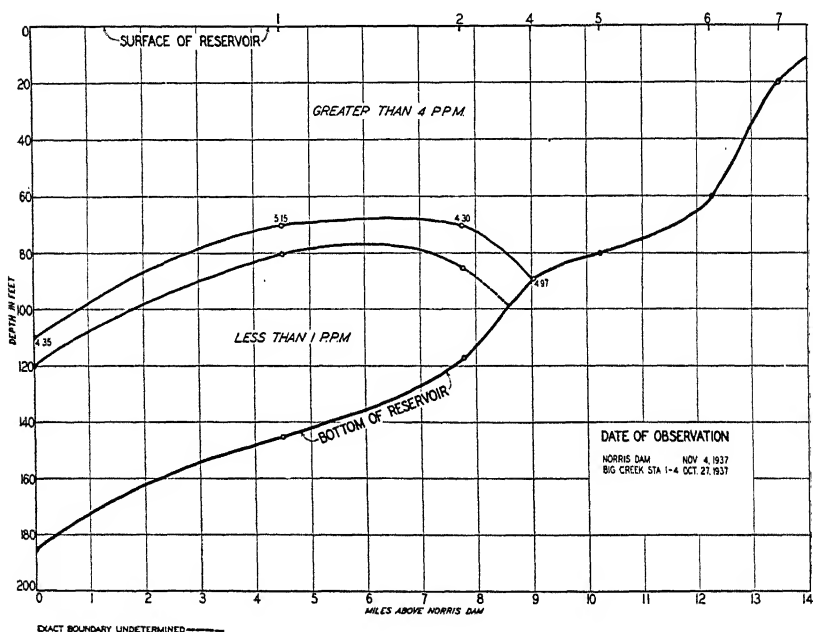
#### DISCUSSION

The following sequence of events explains the atypical stratification of the water in the deeper sections of Norris Reservoir.

- During the fall and early winter as a result of the "fall turn-over" and displacement, practically all indications of stratification disappear—conditions become homogeneous.
- The reservoir is subject to a continuous draw-down. The discharge gates are near the bottom.
- Field observations show that bottom stagnation begins first towards the head of the reservoir. In Big Creek, this stagnation occurs first at a point between stations 6 and 7. There are two reasons why this stagnation sets in here

earlier and proceeds at a faster rate than at #2, for instance: (1) Because of the lesser depth of the water at #6 and #7, the bottom temperatures there are higher than at #2; (2) Another and more important factor in the depletion of D.O. in the upper reaches of the reservoir is the silt carried in by the tributaries, especially after heavy rains. This silt is not all inorganic material, but may contain a considerable amount of organic matter plus the bacteria<sup>2</sup>

FIGURE 5  
DISSOLVED OXYGEN PROFILE  
NORRIS DAM AND BIG CREEK



that exist on this organic matter. When the incoming water hits the backwater at the head of the reservoir, materials suspended in the water begin to settle out. But whether on the bottom or suspended in the water, the silt, as defined above, has an appreciable D.O. demand. The water in the lower and deeper sections of the reservoir carries only a small part of the silt load carried by the water at the head of the reservoir. Hence the oxygen

<sup>2</sup>Whitney, L. V., 1937. Microstratification of the Waters of Inland Lakes in Summer. Science, Vol. 85, No. 2200.

demand is greatly reduced. Table I is offered to prove the difference in D.O. demand in the upper and lower sections of the reservoir. Table II affords additional proof of the high D.O. demand of the water at the head of the reservoir. Furthermore, it suggests that the demand is largely the result of biological activities.

Birge and Juday<sup>3</sup> (1911) report several cases where a diminution of D.O. occurred within a stratum of well

TABLE I

Shows the D.O. present when samples were collected on May 25, 1938, and the amount left after seven and fifteen days of incubation at Stations 2 and 7a. (7a is about 0.5 miles below the No. 7 shown in Figures 1 to 5.) The samples were kept in the dark on the laboratory boat and were subject to variations in temperature. Hence the values in the table are not comparable to B.O.D. values of the sanitary engineer.

STATION	#7a			#2		
	Initial D.O.	D.O. After 7 Days	D.O. After 15 Days	Initial D.O.	D.O. After 7 Days	D.O. After 15 Days
1.....	9.7 p.p.m.	2.8 p.p.m.	0.0 p.p.m.	.....	.....	.....
10.....	9.1	2.1	0.3	10.5 p.p.m.	9.1 p.p.m.	6.2 p.p.m.
20.....	8.7	0.56	0.0	10.6	9.1	6.2
30.....	.....	.....	.....	10.5	8.5	5.7
35.....	8.4	0.7	.....	.....	.....	.....
45.....	7.1	0.0	0.0	.....	.....	.....
50.....	4.9	0.0	0.0	9.3	8.5	5.7
55.....	3.5 <sup>1</sup>	0.0	0.1 (?)	.....	.....	.....
80.....	.....	.....	.....	7.8	7.1	5.7
100.....	.....	.....	.....	7.0	6.3	5.3
120.....	.....	.....	.....	6.6	6.0	4.1
138.....	.....	.....	.....	5.7 <sup>2</sup>	5.2	4.1

<sup>1</sup>Bottom.

<sup>2</sup>Bottom.

aerated water. They ascribed this diminution in D.O. to biological process. (1) Abundant plankton growth occurs within the upper strata of water. (2) The subsequent death of these planktons cause them to sink toward the bottom. However, they begin to decompose before their descent is completed and thus cause a depletion in D.O. within a region that would otherwise be characterized by a high D.O. This explanation holds for the depletion of D.O. in the shallower, upper portions of Norris

<sup>3</sup>Birge, A. E. and Juday, C., 1911, The Dissolved Gasses of the Water and their Biological Significance. No. XXII; Wis. Geo. and Nat. Hist. Sur.

Reservoir if we consider not only the plankton but also the organic matter carried in with the silt and the bacterial fauna of the silt complex. However, to account for the stratum of stagnant water at from 35 to 45 feet, (see Tables I and II again) at station #2 we need an additional factor. Density or subsurface currents as pointed out below would seem to serve this purpose.

- (d) Because of the facts mentioned under (a) and (c), we find at some time during the spring or summer that the water in the lower part of the reservoir has a relatively high D.O. content at all depths while in the upper portions of

TABLE II

Shows D.O. values for samples collected at Big Creek No. 8 on June 28, 1938. At the same time three sets of samples were placed in a dark compartment on the laboratory boat and tested for D.O. as indicated in columns 2 to 4. One set of these samples (column 4) had formalin added as a preservative. All incubated samples were subject to changes in temperature.

Depth, Feet	Initial D.O. 6/28/38	D.O. Left 7/12/38	D.O. Left 7/29/38	7/29/38 D.O. Left in Preserved Samples <sup>1</sup>
1.....	8.8 p.p.m.	3.1 p.p.m.	0.00 p.p.m.	6.0
5.....	8.1	2.7	0.00	6.0
10.....	7.2	2.4	0.48 ?	5.8
15.....	4.9	0.5	0.00	3.6
20.....	3.1	0.5	0.00	2.4
25.....	2.0	0.05	0.00	1.32
29 (b).....	1.4	0.00	0.00	0.9

<sup>1</sup>NOTE: It is possible that not enough preservative had been added. Still there is a marked difference in D.O. values in columns 3 and 4.

the reservoir there exists a surface stratum of well aerated water with a stratum of stagnant water underneath it. That such a condition prevailed in Big Creek during the early summer of 1937 is suggested by Figure 1 and is proven by 1938 observations.

- (e) Under the influence of the draw-down at the dam, the entire mass of water may tend to move towards the dam at a uniform rate at all depths. However, if appreciable differences in density exist, the velocity may not be uniform. The fact that on August 16, 1937, the surface temperature (T.) at the dam was 86° F. and the bottom T. 48.25° F., a difference of 37.75° F., suggests the possibility of a density

gradient due to differences in T. from surface to bottom. (The difference in the surface T. and bottom T. at any given time is a function of the depth of the water.)

The discharge at the dam occurs near the bottom. Thus the colder and heavier water near the outlet will be removed first. This would set up a tendency for all the colder and heavier water to move towards the dam. Under these conditions subsurface or density currents may develop. If these currents have the proper velocity under the prevailing differences in density so as not to lose their identity by diffusion (velocity too low) or by mixing because of turbulence (velocity too high); then it is possible to have the condition found in Norris Reservoir (Figures 1-4), namely, the intrusion of a stratum of stagnant water into a region of water of much higher D.O. content but of the same density as indicated by T.

That such subsurface currents existed is suggested not only by the D.O. but by temperatures as well. For instance, the stagnation zone at #6 on August 20, 1937, extended over the T. range of 78° F.-54.75° F. The so-called intrusion sheet of stagnant water at #2 on the same date covered the T. range of 72.25° F.-59.75° F. Thus the temperature range of the stagnant water (intrusion sheet) at #2 was within the T. range of the stagnant bottom water at #6. The condition just mentioned was general throughout the entire reservoir in 1937.

The data on D.O. and T. would seem to establish the identity of the stagnant bottom water at the head of the reservoir with that occurring at from 35 to 40 feet in the lower sections of the reservoir and suggest the possibility of density currents.

Additional proof that density currents are responsible for the peculiar distribution of D.O. in Norris Reservoir in 1937 have been obtained in 1938. In Big Creek, we have traced a stratum of water of low methylo range alkalinity from the head of the reservoir to #2, a distance of approximately 8 miles. The minimum alkalinity in this stratum occurred at a depth of 40 to 45 feet. This stratum of water moved toward the lower end of the reservoir and in a side view had the form of a wedge. The wedge shape is produced by spreading due to an increase in the cross-section of the reservoir. Again in the Clinch River sector, we have traced several subsurface strata of silt laden waters. One of these strata was followed for a distance of 20 miles. The maximum density, as determined by



turbidity measurements, of this stratum occurred at a depth of from 55 to 65 feet. Under these conditions, the surface water to a depth of 25 feet may be absolutely clear. The same thing is true, only in a lesser degree, of the water below the stratum of very turbid water.

#### CONCLUSION

The atypical distribution of D.O. in Norris Reservoir in general and in the Big Creek Sector in particular as represented in Figures 1 to 5, is due to two factors: (1) the high biological oxygen demand of the water at the head of the reservoir causing stagnation within the hypolimnion, (2) Density currents carrying this stagnant water toward the dam at its characteristic density and temperature level.

#### ACKNOWLEDGMENTS

This investigation was made possible through the sympathetic co-operation of Dr. A. R. Cahu, division chief, and Mr. C. C. Davis, engineer. The services rendered by my assistant, Mr. Edwin Eastwood—an ex-C.C.C.—have been most helpful in the field as well as in the laboratory.

---

#### Comparative Physiology

It has often been said that Physiology is the hand-maiden of Medicine. Certain it is that the development of these two aspects of biological science have to a large extent been parallel and interdependent. It is no doubt largely for this reason that the general and comparative approaches to physiology have been so slow in their development. Dr. Rogers' Textbook of Comparative Physiology, the first edition of which appeared in 1927, is one of the few books on functional biology which is written from the comparative point of view. In General Physiology the emphasis is presumably on principles which apply to living matter in general, while Comparative Physiology would naturally be expected to deal with the variations in these same principles found in going from one group of animals to another. It is obvious that both of these branches of physiology, in common with mammalian physiology, must deal with the same principles. A certain amount of overlapping in textbooks is, therefore, unavoidable and it is to be expected that a considerable part of the material presented in Dr. Rogers' book should be identical with the contents of standard books on general physiology. However, Dr. Rogers has collected and organized in his book a large amount of material on the physiology of the invertebrates not found elsewhere except in the published results of original research. This fact should make the book of much value to the general biologist as well as to the physiologist whose interest extends beyond the limits of the mammalia.

The second edition of Dr. Rogers' Comparative physiology, which has just appeared, has been rearranged and largely rewritten. It also contains much new material, most of which can be found in no other book. The volume should be of considerable value, not only to the student of physiology, but to the research worker as well.—*Fred A. Hitchcock.*

**Textbook of Comparative Physiology**, 2nd edition, by Charles Gardener Rogers. xviii+715 pp. New York, The McGraw-Hill Book Company, 1938. \$5.50.

# VARIATION IN *MONIEZIA EXPANSA* RUDOLPHI

STEPHEN R. WILLIAMS,  
Miami University, Oxford, Ohio

In making a number of preparations of proglottids for class study at the stage when sex organs are mature and before embryos appear and obscure matters, an abnormal set of proglottids was found. None of the fragments mounted were connected with scolices. All had been preserved in formalin, stained with Delafield's hematoxylin, decolorized with one per cent  $\text{HC}_1$  and mounted in balsam.

This piece is mounted dorsal side up with the free edges, right and left, showing the region of the genital pores. The interproglottidal pits surrounded by numerous glands, diagnostic of this group of species of *Moniezia*, show clearly at the distal boundary of each proglottid (that away from the scolex).

This is not the place to argue concerning what a proglottid is, whether a reduplicated sexual portion of a single worm or a sexual individual in itself. It will be enough to say that for the purposes of this paper a tapeworm strobila is considered similar to the strobila of the coelenterate *Aurelia* and a proglottid to a single medusa except that the proglottid is hermaphrodite and the medusa either male or female. In this I am merely classifying myself. According to the discussion in Bronn's *Thier-reich* the theory one will incline to is largely a question of temperament since the phenomena may be interpreted either way.

The abnormality was first noted on the left side where two sets of sex organs appear with no proglottid boundary fully separating them. There is an offset at the edge and a beginning interproglottidal separation which fades out as it reaches the region between the sex organs. Before it ceases it shows several normal pits with glands. On the right side and edge is a single normal set of sex organs. This area described will be spoken of as proglottid Complex Number Two.

On the right side of proglottid Complex Number One, distal to the Complex Two, a similar doubling of sex structures occurs but it is much less distinct and complete.

The sinus and sex ducts which should have appeared distally are not present but a disturbed area indicated by two lines is found where these structures should have arisen.

Anterior to this area is the start of an interproglottidal boundary showing two interproglottidal pouches facing each other. This boundary, however, is deficient in that it does not separate the proximal set of sex ducts from the distal group of sex organs without ducts of their own.

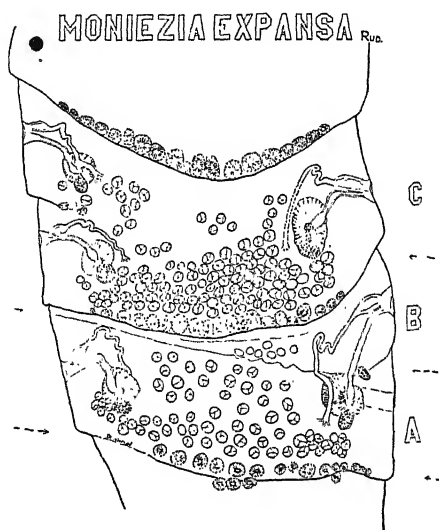


Fig. 1. Abnormal proglottids of *Moniezia expansa*. (+ 12).

Medially from this combination of structures the proglottid line between proglottids A and B is very faint with only a few interproglottidal glands and no pits or pouches. Tracing this line across the proglottid it fades out close to the left edge and very near the distal boundary of Complex Two. In the usual position on the left side of proglottid A is a normal set of sex organs and ducts.

So in what seems to be two consecutive proglottids, Complexes One and Two, there are three complete sets of sex organs on the left and on the right one normal group in proglottid C plus a complex in proglottids A and B which evidently represents two sets of organs.

What has happened may be explained as a disturbance of the divisions between proglottids so that by the dislocation

of parts of two boundaries three proglottids, A, B, C have been concentrated into the two complexes.

This disturbance must have been active at the time when the distal proglottid A was being marked off from the neck of the scolex and its influence persisted during the forming of proglottids B and C. Younger proglottids in this fragment of the strobila are normal.

Stiles and Hassall give data for the development of the *Moniezia* strobila which show when these modifications must have occurred.

The newly attached scolex is from 0.4 mm. to 0.7 mm. long. The first proglottid of the strobila appears 0.5 to 2.0 mm. distal to the constriction or "neck" of the scolex.

The first trace of genital organs appears about proglottid 150, from 7 to 12 mm. behind the scolex, as two clumps of

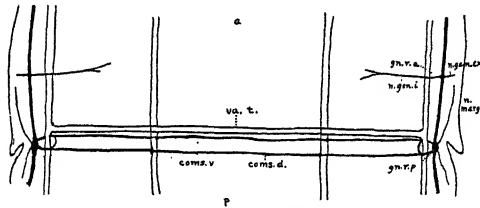


Fig. 2. The nervous system of the cestode *Moniezia expansa*. (Modified from Tower, Fig. 6, Taf. 22.) Coms. d., dorsal commissure of proglottis; coms. v., ventral commissure of proglottis; gn. r. p., right posterior lateral ganglion; gn. r. a., right anterior lateral ganglion; n. gen. ex., external genital nerve; n. gen. i., internal genital nerve; n. marg., marginal nerve; va. t., transverse water tube.

compact tissue 0.5 mm. in diameter, one lying just inside the longitudinal water tube on each side.

At 70 mm. from the scolex each of these clumps, still solid, ends medially in a double knob, the proximal part of which represents the future male organs and the distal portion the female organs. The appearance is roughly that of a pistol with the muzzle pointed outward toward the future genital sinus.

Separate testes are first seen in proglottids 100 mm. from the scolex. They must migrate inward as buds from the male fundament, each separate testis being connected to the vas deferens by its own vas efferens.

Since proglottids are indicated within 2 mm. of the scolex we should examine conditions at that level in interpreting boundaries.

What can be seen of the distal boundary of proglottid A indicates no especial irregularity, so the difficulty may have been with the agencies concerned in the location of the proximal boundary between B and A. Starting on the right this boundary shows two characteristic glandular pouches facing each other across the line. There are other glands not in pouches dispersed irregularly along the faint boundary half way across the proglottid.

The distal sex glands in A, which have no sex ducts, appear to have connected with the proximal ducts across the proglottid boundary.

Testes are present in abundance in proglottid A while only a few rather undeveloped testes appear in proglottid B. There may be a faint trace of an ovary in B proximal to the boundary of A.

The conspicuous distal boundary of Complex Two does not run directly across as one would expect but dipping sharply from the right towards Complex One makes a fairly straight line to the left just proximal and parallel to the rudimentary boundary described between A and B.

The area between these two boundaries is only part of what should have been proglottid B.

Whatever the deflecting influence modifying the direction of boundaries it was not strong enough to extract the small part of the boundary of C starting at the left edge and reaching as far as between the two ovaries. This shows several typical gland pouches along its brief course and ceases abruptly.

Testes are more than usually abundant in the distal portion of Complex Two since there are three sets of normal sex organs inside its boundaries and testes typically tend to develop nearer the boundary away from the scolex.

Is it possible to explain these abnormalities as results of deficient developments in the nervous system? Tower in his paper on the nervous system of *Moniezia* states on p. 373: "For the first five mm. behind the scolex the lateral nerves are of uniform diameter, they possess only a few ganglionic cells and no trace of ganglionic enlargements." "In the posterior part of the neck region where the proglottids begin to be distinguishable the nerves begin to assume the condition which they present in the mature segments." "Each lateral nerve begins to exhibit an enlargement at a point near the posterior margin of the proglottis." (The first indication

of the posterior lateral ganglion.) "The position of these ganglia is indicated in the preceding portion of the neck region by the presence of small branches from the lateral nerve which correspond in position to the posterior part of each young proglottis." (Undoubtedly the beginnings of the dorsal and ventral commissures, recognizable before the ganglia with which they connect have arisen.) "At a distance of 30 mm. from the scolex the posterior lateral ganglia are well marked."

These posterior lateral ganglia together with the dorsal and ventral commissures would seem to correspond roughly to the ring nerve in a medusa. This ring of nerve tissue is likely the especial correlating element when the single adult proglottid swims (as to my surprise I have seen it do).

Suppose that in some way the nervous tissue of the right side in proglottid B was damaged in such a way that the dorsal and ventral commissures never connected from the two sides. Since these commissures appear so early such a deficiency may explain the lack of a typical proximal boundary for proglottid A.

The absence of this boundary, or rather of the nervous tissues which initiate the forming of the boundary may have influenced the location of the proximal boundary which should have separated B from C. This starts normally on the right and is rapidly bent distally so that it reaches the left side almost upon the rudimentary boundary mentioned between B and A.

As a result most of the proglottid tissue which should have been in B, including the distal set of sex organs and ducts on the left side are now in Complex Number 2. Except for the sex ducts on the right in B it contains only a few insignificant testes and a trace of an ovary too indefinite to be represented.

On the left of Complex 2, in front of the distal sex structures just mentioned, there is definitely the start of the normal boundary between B and C showing several typical glandular pouches and then stopping abruptly.

The difficulty, whatever it was, seems to have started on the right side of the distal proglottid A. I am suggesting this since the lack of the external genital nerve from the anterior lateral ganglion at that point would result in the non-development of sex ducts and gonopore.

The connectives which should foreshadow the dorsal and ventral commissures of the right side of B, indicating the location

of the future posterior lateral ganglion, probably never appeared, so nothing was present to join the corresponding fibers from the left of B.

It is also likely that the internal genital nerve from the anterior lateral (right) ganglion of B was abnormal so no ovary and only a few testes are shown there. The regular sex ducts in B, for lack of their own glands, evidently connected through the rudimentary boundary to the sex glands of A whose ducts never developed.

Those branches on the right side which normally would have aided in forming the dorsal and ventral commissures of C probably developed freely out into the tissue between C and A making connection with the branches on the left side of B which had found no fibers on the right side of B with which to unite. This would explain the distal bending of the boundary half way through the proglottid and its straight path from that point to the left side. The glandular pits would develop along the line determined by the path of the dorsal and ventral commissures.

Since the fibers representing the left connectives of C had no opposites remaining to unite with, they probably degenerated after initiating the start of the left distal boundary sufficiently so that three glandular pits developed along that beginning. By the time the next proximal proglottid was to be divided off from C, the disturbance, whatever it was, had disappeared since the proglottid boundaries from this point on in the fragment are normal.

#### REFERENCES

- Child, C. M. 1900. Abnormalities in the Cestode *Moniezia expansa*. Biol. Bull. I: 215-250, 261-290; 1903 *ibid.*, II: 95-114, 141-160.  
Stiles, C. W. and A. Hassall. 1893. A Revision of the Adult Cestodes of Cattle, Sheep and Allied Animals. U. S. D. A. Bureau Animal Ind., Bull. 4.  
Tower, W. L. 1900. The Nervous System of the Cestode *Moniezia expansa* Rud. Zool. Jahrbücher XIII abt. f. Morph. H. 3: 349-384. Taf. 21-26.

---

#### A Laboratory Manual

In collaboration with Dr. Ivon R. Taylor, Dr. Mitchell has prepared a laboratory guide which is designed to supplement his text-book on General Physiology. The experiments listed cover a wide variety of subjects including the conventional experiments on muscle-nerve, respiration, circulation, and digestion, as well as much material taken from the field of the bio-chemist and the physical chemist. The directions given are quite adequate and clearly and concisely expressed.

—Fred A. Hitchcock.

**Laboratory Manual of General Physiology**, by Philip H. Mitchell and Ivon R. Taylor. xv+142 pp. New York, The McGraw-Hill Book Company, 1938. \$1.50.

# SNOWFALL MAPS OF OHIO

FRED A. CARLSON,

Department of Geography,  
The Ohio State University

To present an accurate representation of the snow cover of Ohio is extremely problematical. The results are not much more than estimates in view of such known limitations as (1) the difficulty of securing a true measurement of snowfall, (2) the insufficient number of well distributed climatological stations, (3) the inadequate number of stations with records for the same period of time, (4) the short duration of the records, and (5) the incompleteness of the data, that is, there are only a few stations with uninterrupted records.

The average annual snowfall map of Ohio, dated to 1937, is based on all of the climatological and first order stations with records for fifteen years or more.

The pattern depicts the heaviest mean annual snowfall in the extreme northeastern counties and the lightest along the Ohio River and in the Scioto Valley. The relation of altitude and snowfall is strikingly apparent. Only minor differences exist between the above map and an average snowfall chart prepared by Mr. William H. Alexander (1921).<sup>1</sup> In general it may be said that the snowfall from 1921 to 1937 has somewhat lightened the mean annual snowfall cover. The difference, however, is not extremely significant and may be partly due to human factors in obtaining station measurements or in the preparation of the isopleths. If two or three of the unusually heavy snowfalls were deleted, the resultant map would be appreciably different from those prepared from all records of fifteen years or more. Particularly, the record snowfall of 1910, when the station amounts ranged from about 35 inches in the southern portion of Ohio to about 125 inches in the northeastern counties. The average for the state, 60.1 inches, was about double the usual amount and was greater than for any other year of record.

---

<sup>1</sup>William Henry Alexander, "A Climatological History of Ohio," Engineering Experiment Station, Ohio State University, Bul. 26, p. 105, 1923.



In the introductory paragraph some of the difficulties encountered in the preparation of snowfall maps were cited. One of these, the lack of complete records, warrants further

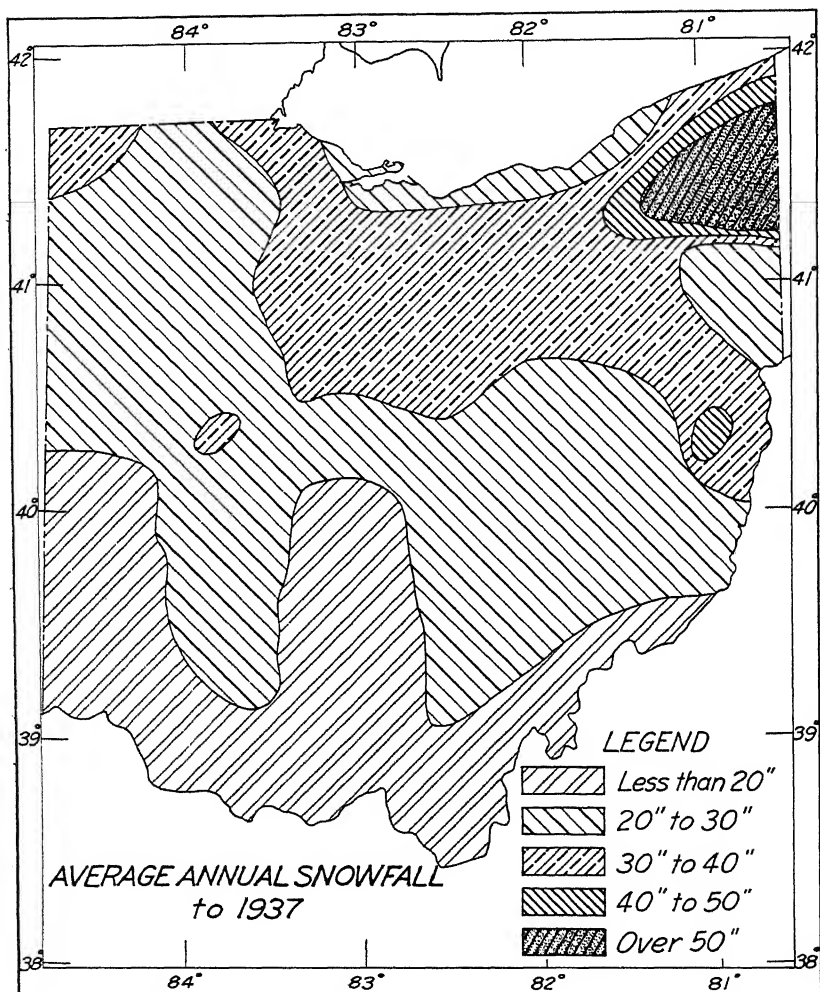


Fig. 1. Average annual snowfall of Ohio to 1937. Based on all climatological and first order stations with records for fifteen years or more.

emphasis. For innumerable reasons, there are only a comparatively few stations with records unbroken and for the same period of time. The original climatological records

"Climatic Summary of the United States," on snowfall are in part based upon interpolation. From more than 70 stations disclose emphatically that the climatic data, published in the

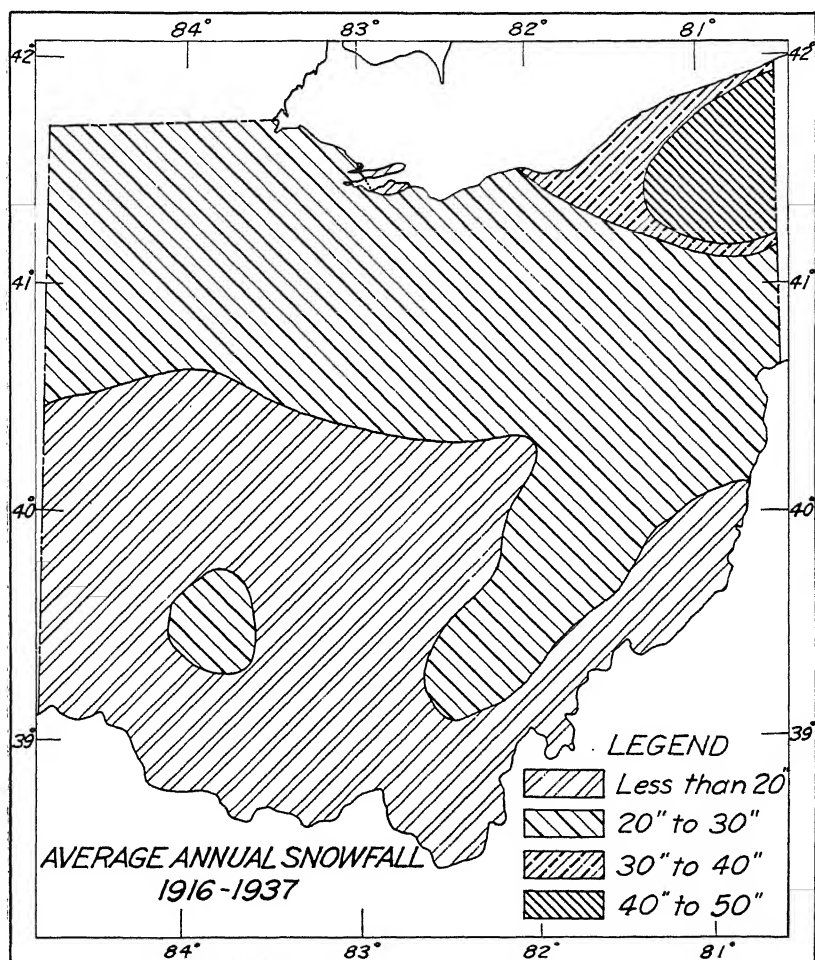


Fig. 2. Average annual snowfall of Ohio, 1936-1937. Based on data of 22 stations of uninterrupted records for the same period of time both in length and in calendar years.

in Ohio, with length of record of fifteen years or more, it is possible to secure only 22 stations of uninterrupted records for the same period of time both in length and in calendar

years. On the basis of the selected station, the map dated 1916-1937 was prepared. While this map is free from interpolation, it is constructed on the basis of so few stations that

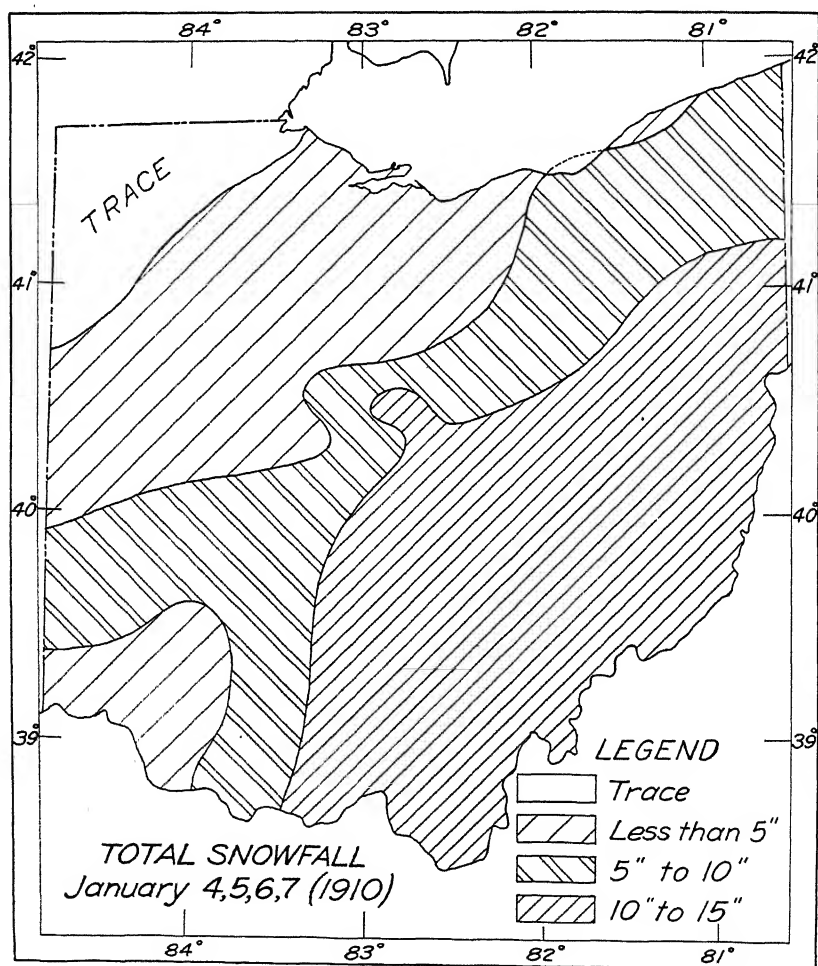


Fig. 3. Period of snow storm in Ohio for January 4, 5, 6, and 7 (1910).

it is probably not as representative of the mean annual snowfall of Ohio as the one previously cited.

Undoubtedly, the climatological interpretation of the distribution of Ohio's snowfall is the foremost question. The

method of procedure was to study periods of snow storms. For this occasion the heavy snowfalls of 1910 is reviewed. The accompanying maps and others not included suggest a preliminary summary as follows:

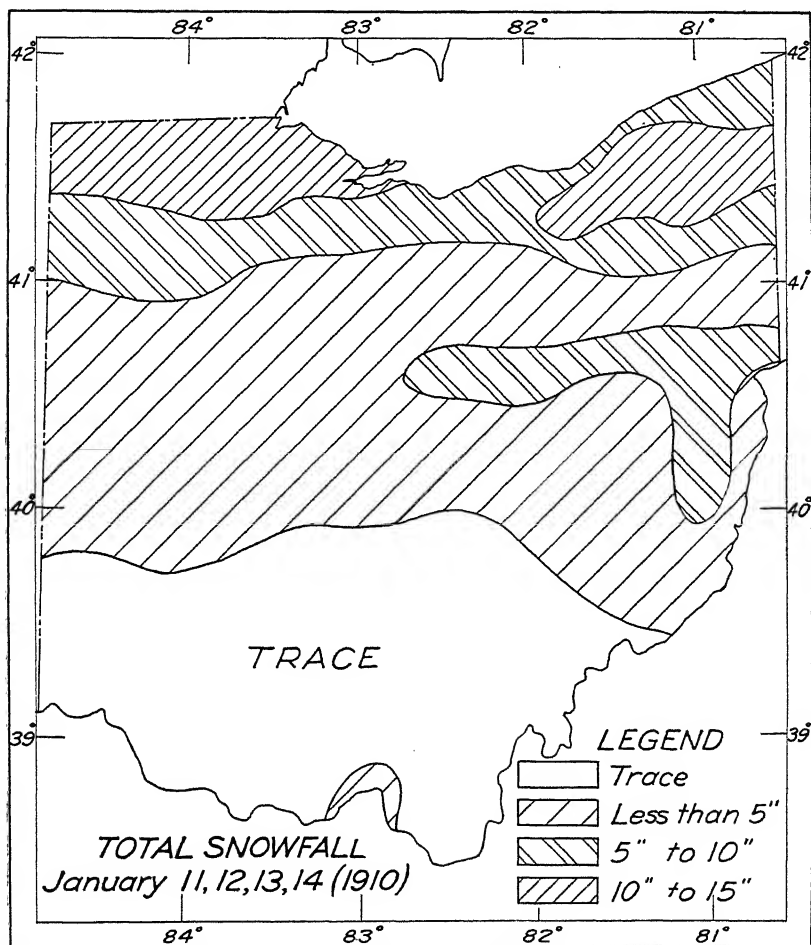


Fig. 4. Period of snow storm in Ohio for January 11, 12, 13 and 14 (1910).

(1) That the snow cover over the entire state is primarily associated with air masses. January is the month of greatest snowfall, followed by December and February.

(2) The excess snowfall in northeastern Ohio suggests a lake, wind, and relief association.

# SPIDERS AND INSECTS FOUND ASSOCIATED WITH SWEET CORN, WITH NOTES ON THE FOOD AND HABITS OF SOME OF THE SPECIES

## III. HYMENOPTERA

RAY THOMAS EVERLY,  
Holmesville, Ohio

### HYMENOPTERA

This order is well represented among the insects collected in the cornfield. Some were reared from hosts collected upon the corn plants. Determinations were made by Mr. H. G. Barber, Mr. R. A. Cushman, Mr. A. B. Gahan, Mr. Wm. Middleton, Mr. C. F. W. Muesebeck, Mr. G. A. Sandhouse, Mr. M. R. Smith, Mr. E. S. Thomas, and Mr. L. H. Weld.

#### Andrenidae

*Melissodes bimaculata* LeP. Five specimens taken July 29 to late August.

This species was taken as the prey of *Protacanthus milbertii* Macq., (Diptera-Asilidae), on July 29, August 14, and late August.

#### Apidae

*Apis mellifera* L. Two specimens taken July 15 and August 3.

This species visited the corn plants throughout the season while the plants were shedding pollen. Some of the strains of corn had a fragrant odor when in tassel and attracted many honeybees.

#### Argidae

*Sterictiphora zabriskiei* (W. & M.). Five specimens taken July 31 to late August.

#### Bembicidae

*Bembix spinolae* Lep. One specimen collected August 5.

#### Bethylidae

*Dissomphalus* (?) *n. sp.* One male specimen taken July 24.

*N. Gen.* (?) *n. sp. near Dryinopsis* Brues. One specimen taken August 5.

*Pseudisobrachium sp.* One specimen taken August 2.

#### Bombidae

*Bombus americanorum* Fab. Two females taken July 8 and 20.

*Bombus auricomus* Robt. One male taken August 13.

*Bombus impatiens* Cress. One specimen collected July 8.

This specimen was taken as the prey of *Protacanthus milbertii* Macq., (Diptera-Asilidae). As in the case with the honeybees, specimens of

this family were frequent visitors upon the tassels of the corn plants while they were shedding pollen. The pollen baskets of the specimens captured were filled.

### Braconidae

*Apanteles* sp. One specimen taken July 18.

*Aphidius rosae* Hal. Two specimens taken July 10 and 11.

*Chelonus* sp. One specimen taken July 18.

*Dinocampus coccinellae* (Schrank). Four specimens reared from adult Coccinelids, collected from July 18 to late August.

This species was reared from *Ceratomegilla fuscilabris* Muls., *Hippodamia convergens* Guer., *Hippodamia parenthesis* Say, (Coleoptera-Coccinellidae).

*Euphorina uniformis* Gahan. Two specimens taken July 11 and 15.

*Microbracon* sp. One specimen taken August 5.

*Microplitis maturus* Weed. One specimen collected July 18.

*Microplitis melianae* Vier. One specimen collected July 18.

*Microtonus* (see Syrrhizus).

*Opius* sp. One specimen taken August 8.

*Opius utahensis* Gahan. One specimen taken August 5.

*Syrrhizus* (*Microtonus*) *agilis* (Cress.). One specimen taken July 13.

### Ceraphonidae

*Conostigmus* sp. One specimen taken July 13.

### Chalcididae

*Halticoptera aenea* Walk. One specimen taken July 18.

### Cynipidae

*Psilodera* sp. One specimen taken July 11; "parasitic on Dipteron larvae breeding in cow manure."

### Diapriidae

*Trichopria* sp. One specimen taken July 11.

### Eucharidae

*Pseudometagea schwarzii* Ashm. One specimen collected July 10.

### Eulophiidae

*Diaulinus websteri* Cwfd. One specimen taken July 11.

*Phygadeuon* n. sp. One specimen taken July 11.

### Formicidae

*Formica* sp. Five specimens taken July 16 to August 25.

*Formica fusca subaenescens* Emery. Two workers taken August 6.

*Formica fusca subsericea* Say. Many workers taken August 2 to 8.

This species was taken in attendance upon an undetermined species of Aphid, upon the tassel of a corn plant. Whenever any adult cocci-

nellids were placed in the vicinity of the aphids they were immediately attacked by one or more of the ants and knocked from the plant.

*Lasius niger americana* Emery. One worker taken July 13.

*Lasius niger neoniger* Emery. Two workers taken July 15 and 31.

*Ponera coarctata pennsylvanica* (Buckley). Worker taken in late August.

*Prenolepis imparis* (Say). Many workers taken July 22 to August 7.

On the roadway between the plots, on July 25, one worker of this species was observed dragging a larva of the European corn borer.

*Pyrausta nubilalis* Hbn., (Lepidoptera-Pyralidae).

*Tapinoma sessile* (Say). One female taken July 15.

### Halictidae

*Halictus illinoensis* Robt. One specimen taken July 14.

*Halictus parallelus* Say. One specimen taken July 17.

*Halictus rubicundus* Christ (?). One specimen taken August 2.

*Halictus versatus* Robt. One specimen taken August 7.

### Ichneumonidae

*Amblyteles longulus* (Cress.). One specimen taken July 12.

*Diplazon laetatorius* (Fab.). Two specimens taken July 9 and 17.

*Epiurus indigator* (Cress.). One specimen taken July 12.

*Enicospilus purgatus* (Say.) Two specimens taken July 28 and late August.

*Phygodeuon* sp. One specimen taken August 7.

*Phygodeuon subfuscus* Cress. One specimen taken August 2.

*Promethes costalis* (Prov.). One specimen taken July 16.

*Sagaritis oxylus* (Cress.). Two specimens taken July 10 and 17.

*Sagaritis provancheri* (D. T.). Two specimens taken July 11 and 18.

*Zamicrotoridea syrphicola* (Ashm.). Two specimens reared from undetermined Syrphid larvae.

The hosts of the above species was probably a species of *Baccha*, (Diptera-Syrphidae), as a larva, determined as *Baccha* sp., was taken upon the same corn leaf with the parasitized larvae. Collected July 29.

*Zootrepes compressiventris* (Cress.). One specimen taken July 18.

### Megachilidae

*Megachile latimanus* Say. One specimen taken July 8.

### Mutillidae

*Timulla* sp. Two specimens, a male and a female, taken July 17 and 25.

Specimens of this family were quite numerous in the roadways between the plots.

### Scelionidae

*Paridris brevipennis* Fouts. One specimen taken July 18.

*Telenomus podisi* Ashm. Reared from the eggs on an undetermined pentatomid.

The host of this species was possibly *Euchistus variolarius* (P. de B.), (Hemiptera-Pentatomidae), as this species was extremely abundant in the cornfield.

### Sphecidae

*Chalybion cyaneum* (Fabr.). One specimen taken July 5.

*Lindenius errans* Fox. Two specimens taken July 13 and August 7.

*Notoglossus* (see *Oxybelus*).

*Oxybelus* (*Notoglossus*) *sp.* One specimen taken July 15.

*Oxybelus* (*Notoglossus*) *emarginatus* Say. Two specimens taken mating on August 13.

*Sphex urnarius* (Dahl.). Two specimens taken July 12 and late August.

The specimen above, collected in late August, had, as its prey, a larva of an undetermined species of *Plusia*, (Lepidoptera-Noctuidae).

### Tetrastichidae

*Tetrastichus sp.* One specimen taken August 13.

---

### Botany

The book is designed as a text for one semester of elementary botany or for the first half of a biology course. It deals in a simple way with some of the basic facts and principles of plant science. The organization is rather unique, permitting the instructor to interest his class in the first lessons with discussions of plants as they have been observed by the student in the field. Sections concerned with root types, leaf arrangements, buds, stem types, and leaf types are followed by one on vegetative reproduction.

With a knowledge of the gross structure of plants as a background, the author proceeds with a more critical examination of cells and vegetative tissues. The more important physiological relationships and processes are discussed. The subject of growth substances is disposed of in two sentences. The author apparently considers the external environmental factors all important in determining plant distribution since little or no reference is made to the physiology of the plant in this connection. Considerable attention is given to the subjects of flower parts and seed classification. Chapters on floral evolution, pollination, seeds and seedlings are followed by one dealing with heredity and plant breeding.

The last half of the book is reserved for a survey of the plant kingdom, a discussion of characteristics of the chief families of Angiosperms, and fossil plants. Evolution, heredity and adaptation have received special consideration. Plant examples have been taken from among those most familiar to the student. Illustrations are well chosen, abundant, and finely reproduced. Throughout the book the author assigns functions to the organs and tissues. Purposeful explanations are frequently given. Morphology assumes the limelight while very little attention is paid to the physiological status of the plant with regard to structure, distribution, or the expression of hereditary potentialities.—R. A. Popham.

**An Introduction to Botany**, by Arthur W. Hampt. xii+396 pp. New York, The McGraw-Hill Book Co., 1938. \$3.00.



# SPIDERS AND INSECTS FOUND ASSOCIATED WITH SWEET CORN, WITH NOTES ON THE FOOD AND HABITS OF SOME SPECIES

## IV. DIPTERA AND HEMIPTERA

RAY THOMAS EVERLY,

Holmesville, Ohio

### DIPTERA

This order is well represented in the field, but due to inability to use better collecting and preservation methods, most of the determinations could only be made to the genus. However, the identifications listed will give a fairly accurate representation of the families and genera present among the corn plants. Determinations were made by Mr. S. W. Bromley, Mr. C. T. Greene, Mr. D. G. Hall, Mr. J. N. Knull, Mr. R. C. Osburn, and Mr. Allan Stone.

#### Agromyzidae

*Agromyza* sp. Four specimens taken July 13 to August 8.

#### Asilidae

*Asilus notatus* Wied. One specimen collected July 21.

*Erax aestuans* L. Three specimens taken July 16, August 5, and August 11.

*Proctacanthus milbertii* Macq. Seven specimens collected July 8 to late August.

Three of the above specimens, collected July 29, August 14, and late August, were preying upon the melon bee, *Melissodes bimaculata* LeP., (Hymenoptera-Andrenidae). One, collected on August 14, was preying upon a bumble-bee, *Bombus impatiens* Cress., (Hymenoptera-Bombidae). Another specimen, collected on August 13, was feeding upon an adult stink bug, *Euchistus variolarius* P. de B., (Hemiptera-Pentatomidae).

#### Borboridae

*Leptocera* sp. One specimen taken July 5.

#### Ceratopogonidae

*Forcipomyia* sp. One specimen taken July 14.

#### Chamaemyiidae

*Leucopsia* sp. One specimen collected July 18.

#### Chironomidae

*Chironomus* sp. One specimen collected July 18.

*Chironomus tentans* F. Two specimens taken July 17.

*Clinotanytus scalpularis* (Lw.). Four specimens collected July 10 and 28.

**Anthomyidae**

*Anthomyidae* sp. "Poor condition," taken July 12 and 28, two specimens.

**Chloropidae**

*Botanobia* sp. Five specimens taken July 10 to 18.

*Chloropsica* sp. Three specimens collected July 18 to August 7.

*Crassiseta* sp. Four specimens taken July 11 to August 9.

**Culicidae**

*Aedes vexans* (Mg.). One specimen taken late August.

**Dolichopidae**

*Chrysotus* sp. Two specimens collected July 11.

**Ephydriidae**

*Psilopus siphon* Say. Three specimens taken July 24 to August 7.

**Lauxanidae**

*Pachycerina* sp. Two specimens collected July 13 and 19.

**Metopiidae**

*Pollenia rudis* Fabr. Five specimens taken July 24 to late August.

*Sarcophaga falculata* Pand. Two specimens taken July 15.

*Sarcophaga lherminieri* RD. One specimen collected late August.

**Muscidae**

*Phaeniinae* near *Pseudophonia*. One specimen taken July 29.

*Musca domestica* L. One specimen taken August 7.

*Myiopina* RD. sp. Eight specimens taken July 11 to August 8.

*Myiopina* sp. Four specimens taken July 11 to August 7.

**Otitidae**

*Chaetopsis fulvifrons* Macq. Three specimens taken July 9 to 28.

*Tetanops luridipennis* Lw. Three specimens taken July 12 to August 5.

**Phyllomyzidae**

*Milichiella* sp. Two specimens taken July 14 and 16.

**Sciaridae**

*Sciara* sp. Three specimens taken July 10 to 11.

*Sciara jacunda* Joh. One specimen taken August 3.

**Stratiomyidae**

*Johannsenomyia albaria* (Coq.). One specimen taken July 29.

*Odontomyia varipes* Loew. One specimen taken July 9.

*Odontomyia vertebrata* Say. One specimen taken July 12.

*Stratiomys badius* Walk. One specimen taken August 5.

### Syrphidae

The larvae of this family were very abundant upon the leaves of the corn plants. None were observed to feed. *Zamicrotoridea syrphicola* (Ashm.), (Hymenoptera-Ichneumonidae), was reared from an undetermined larva of this family, possibly a species of *Bacchus* sp., as a larva of this genus was taken upon the same leaf with the parasitized specimen.

*Bacchus* sp. One larva taken upon the corn leaf July 29.

*Eristalis arbustorum* L. One specimen collected July 14.

*Platychirus quadratus* Say. Four specimens taken July 9 to 28.

*Mesogramma marginata* Say. Three specimens taken July 14 to 16.

*Mesogramma polita* Say. One specimen reared from a puparium found on a corn leaf July 19.

*Metasyrphus wiedemani* Johnson. One specimen collected July 25

*Toxomerus geminatus* Say. One specimen taken July 13.

### Tachinidae

*Achaetoneura* sp. One specimen taken August 2.

*Archytas* near *analis*. One specimen taken July 17.

*Exorista* sp. Two specimens taken July 8 to August 5.

*Linnaemyia* RD. sp. One specimen taken feeding upon exudations from European corn borer tunnel in sweet corn plant.

*Microptthalma* sp. One specimen taken July 12.

*Paradmontia* sp. One specimen taken July 11.

*Tachinidae* sp. One specimen in "poor condition," taken July 28.

### Tetanoceridae

*Sepedon fuscipennis* Lw. One specimen taken August 1.

### Therevidae

*Psilocephala* sp. Four specimens taken July 10 to August 5.

### Tipulidae

*Nephrotoma ferruginea* (F.). One specimen taken July 11.

*Tipula* sp. One specimen taken July 8.

### Trupaneidae

*Euaresta bella* Lw. Two specimens taken July 14 and August 9.

## HEMIPTERA

This order was very abundant in the corn field, especially in the individuals of the species. Some were observed preying upon other insects and some attacking the corn plant itself. The following determinations were made by Mr. J. S. Hambleton.

### Anthocoridae

#### *Triphelps insidiosus* Say

This species occurred very commonly throughout the cornfield upon the corn plants, both as nymphs and adults. It was commonly observed in the tassels and ear silks, and was very abundant between the leaf sheaths and the stalk. It readily bites humans and was quite annoying while working among the corn plants during July and August. This species has been noted as an important predator of the corn ear worm larvae, and this fact, coupled with abundance of the insect during July and August among the tassels and at the base of the corn leaves, suggests that it may also be an important predator of the eggs and newly-hatched European corn borer larvae, *Pyrausta nubilalis* Hbn.

### Corimelaenidae

*Corimelaena pulicaria* (Germar). Five specimens taken July 25 to August 5.

*Galupha nituloides* (Wolff). One specimen taken July 28.

### Coryzidae

*Corizus lateralis* (Say). One specimen taken late in August.

### Lygaeidae

*Blissus leucopterus* Say. Common upon corn stalks under leaf sheaths at base of plants. Taken from July 8 to late August.

*Geocerus bullatus* (Say). One specimen taken July 28.

*Myodocha serripes* Olivier. Two specimens taken August 14.

### Miridae

*Adelphocoris rapidus* (Say). Six specimens taken July 8 to August 7.

*Chlamydatus* sp. Abundant upon the corn plants. Taken July 12 to 18.

*Lygus praetensis* (L.). Common in the field throughout the season.

This species was taken as the prey of *Nabis ferus* (L.), (Hemiptera-Nabidae).

*Lygus praetensis strigulatus* Walker. One specimen taken July 11.

*Plagionathus annulatus cuneus* Knight. One specimen taken July 9.

*Semium hirtum* Reuter. One specimen taken late in August.

*Trigonotilus ruficornis* (Geoffroy).

This species was very abundant during the latter part of July and early August. It was taken as the prey of *Ceratomegilla fuscilabris* Muls., (Coleoptera-Coccinellidae).

### Nabidae

*Nabis ferus* (L.). Common on the corn plants and under debris upon the ground. July 8 to August 14.

This species was taken preying upon *Lygus praetensis* (L.), (Hemiptera-Miridae).

*Nabis roseipennis* Reuter. One specimen taken August 3.

*Pagasa pallipes* Stal. One specimen taken August 1.

### Pentatomidae

*Euchistus variolarius* (P. de B.)

This species was commonly observed in the field from July 9 to August 9. It was noted upon several occasions with the beak inserted into the stalks and leaves of the corn plants. It was taken as the prey of *Proctacanthus milbertii* Macq., (Diptera-Asilidae). Eggs, of an undetermined pentatomid, possibly this species, were found parasitized by *Telenomus podisi* Ashm., (Hymenoptera-Scelionidae).

*Perillus bioculatus* (Fab.)

This species was taken upon black nightshade, *Solanum niger* Nutt., growing in the roadway of the plot on August 22, feeding upon a larva of *Lema trilineata* Oliv., (Coleoptera-Chrysomelidae). This larva was determined by Dr. A. G. Boevig.

*Thyanta custator* (Fab.). Three specimens taken July 17 to 19.

### Piesmidæ

*Piesma cinerea* (Say). Quite common on the leaves of the corn plants, taken July 9 to 28.

### Reduviidae

*Sinea diadema* (Fab.). One specimen taken July 17.

### Tingitidae

*Corythca marmorata* (Uhler). Taken July 9 to 19. Very abundant early in July but not seen after July 19.

---

### Science in Retrospect

There appears to be an increasing realization among scientists that the history of scientific thought in relation to the social and economic background of the time is of value, both for its own sake and for the insight it offers into modern trends in scientific development. With this thought in mind a great university which itself has contributed much to scientific history has inaugurated a series of courses of lectures covering the development of science in specific historical periods. The first of these courses, covering in most of the lectures the period from 1895 to 1935, provides the subject matter of the volume under discussion. The presentations are well thought out and admirably condensed to lecture length. Most of the contributors have chosen to follow intensively specific parts of their fields rather than to attempt broad historical analyses. The lecturers and their subjects are as follows: Cornford on philosophy, Dampier on the period from Aristotle to Galileo, the late Lord Rutherford on physics, Bragg on crystal physics, Aston on atomic theory, Sir Arthur Eddington on astronomy, Ryle on physiology and pathology, the late G. H. F. Nuttall on parasitology and tropical medicine, Punnett on evolution, and Haldane on genetics. The various chapters are intensely interesting and are written with an enthusiasm and vigor which can not help captivating the reader.

—L. H. S.

**Background to Modern Science**, by a series of contributors, edited by Needham and Pagel. xii+243 pp. Cambridge, at the University Press; in New York, The Macmillan Co., 1938. \$2.00.

# THE DIGESTIVE SYSTEM OF MACROSIPHUM SOLANIFOLII (ASH.)

(APHIDAE: HOMOPTERA)

CLYDE F. SMITH,

Ohio State University

This work was undertaken as a special problem on the internal anatomy of insects. The Aphid, *M. solanifolii* (Ash.) was chosen because of the writer's interest in the Aphidae, the economic importance of this particular aphid, and the fact that so far as known an account of the digestive system of an aphid in this genus has not been published.

The writer is indebted to Dr. C. H. Kennedy, under whom this work was carried on, for his suggestions and criticisms as the work progressed.

The digestive tract is rather simple in the Aphidae, consisting of a coiled tube. In *M. solanifolii* it is approximately three times the length of the body, lies slightly ventrad to the center of the body and is folded as illustrated (Fig. 1). The various parts of the tube are free and not closely associated or joined with the other portions of the tube. Apparently this is the case with a good many species of aphids. However, Knowlton, 1925, in reporting on *Longistigma caryae* (Harris), states: "For a short distance the tube is complicated by the anterior end of the mid-intestine doubling back and forming a loop through the muscle wall of the posterior end of the mid-intestine and the anterior end of the hind-intestine. This loop enters through the muscle wall of the hind-intestine and enlarges where the folds of the oesophageal valve return and join the stomach epithelium."

Morphologically the alimentary tract consists of three parts, the fore-, mid-, and hind-intestine. In *M. solanifolii* the union of the fore- and mid-intestine is marked by the oesophageal valve (Fig. 4) which extends into the lumen of the mid-intestine. The union of the mid- and hind-intestine (Fig. 3) is not well defined because the pyloric valve and malpighian tubules are lacking. The mid-intestine gives way to a rather structureless hind-intestine. A similar condition was found by Knowlton in *L. caryae* but Pelton (1937) states, "The pyloric valve (*Prociphilus tessellata* (Fitch)) consists of

a slight constriction and differentiation of cells. The large irregular cells of the mid-intestine end abruptly and the irregular columnar cells of the hind-intestine arise."

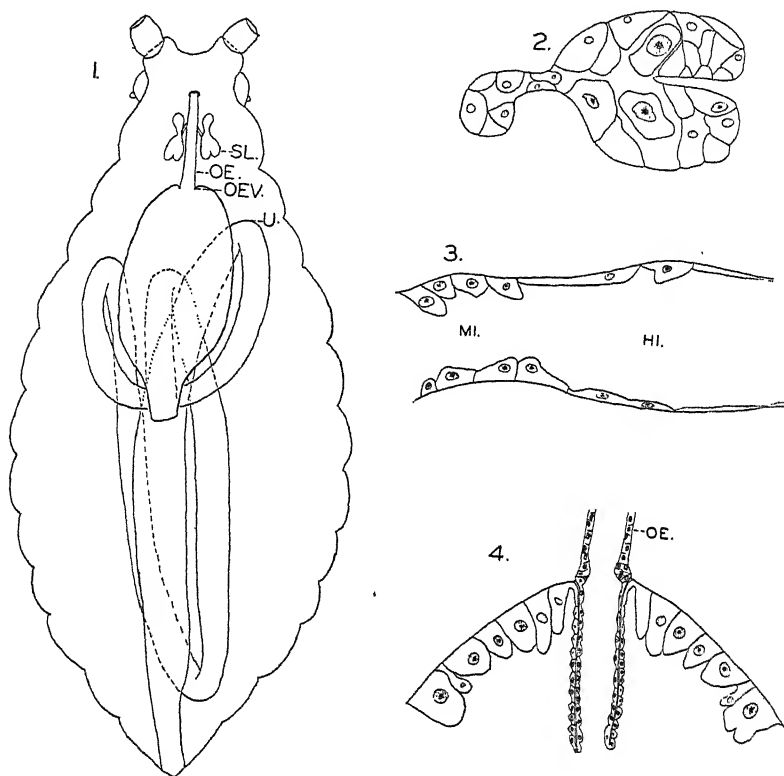


Fig. 1. Dorsal view of the alimentary canal.

Fig. 2. Longitudinal section of salivary gland, showing anterior and posterior lobes and posterior notch as outlined in the left gland in Figure 1.

Fig. 3. Longitudinal section at union of mid- and hind-intestine.

Fig. 4. Longitudinal section through a portion of the oesophagus, the oesophageal valve and part of the stomach.

#### EXPLANATION OF ABBREVIATIONS

HI—hind-intestine.

MI—mid-intestine.

OE—oesophagus.

OEV—oesophageal valve.

SL—salivary gland.

U—union of mid- and hind-intestine.

#### THE DIGESTIVE SYSTEM

The mouth or oral opening is situated on the ventral surface of the head, bounded anteriorly by the labrum and posteriorly by the labium. Laterally it is bounded by the mandibles and maxillae.

The mouth opens upward into a relatively large, distensible chamber, the pharynx. The pharynx is well supplied with muscles, the majority of which are attached to the anterior flexible wall. The posterior or ventral wall is strengthened by a stout layer of chitin. As seen in transverse sections the pharynx is crescentic in shape, its greatest transverse diameter being near the oral end.

The salivary glands lie obliquely in the thorax, above the oesophagus, and consist of a small anterior gland and a large posterior gland, situated on each side of the median line. The salivary duct from each side unites in the mid-ventral line with the duct from the opposite side to form a median salivary duct which opens at the posterior end of the buccal cavity.

The oesophagus is a long slender tube leading from the pharynx, up over the tentorium to the stomach. The posterior end of the oesophagus projects into the stomach, or the dilated region of the mid-intestine, forming the oesophageal valve.

The oesophageal valve (Fig. 4), as seen in longitudinal sections, consists of the invagination of the oesophagus into the stomach, its walls being reflected back to become continuous with the walls of that structure.

The mid-intestine is marked anteriorly by the oesophageal valve and posteriorly by the rather structureless hind-intestine. The anterior portion of the mid-intestine is considerably enlarged to form the stomach which is the widest part of the alimentary canal.

The pyloric valve is not present. The most evident mark of transition from the mid- to the hind-intestine is the ending of the large epithelial cells of the mid-intestine, and the beginning of the long, thin cells of the hind-intestine.

The hind-intestine connects with the anus by the rectum which horizontally has a wide, thin opening through the center.

#### BIBLIOGRAPHY

1. Davidson, J. 1913. The structure and biology of *Schizoneura lanigera* Haus. or woolly aphid of the apple tree. Quart. Jour. Micro. Sci. n. s. 58: 653-703.
2. Dufour, Léon. 1833. Recherches anatomiques et physiologiques sur les Hemiptères. Mem. pres. a l'instit. de France, Tome IV, Aphidiens, pp. 241-245, 359, 369, 387 and 418.
3. Grove, A. J. 1909. The anatomy of *Siphonophora rosarum* Walk., the "Green-fly" pest of the Rose-tree. Part I. The apterous viviparous stage. Parasitology, 2: 1-28.
4. Knowlton, G. F. 1925. The digestive tract of *Longistigma caryae* (Harris). Ohio Jour. Sci. 25: 244-252.
5. Pelton, J. Z. 1937. The alimentary canal of the aphid, *Prociphilus tessellata* (Fitch). M. S. Thesis. Ohio State University (Unpublished).
6. Weber, H. 1930. Biologie der Hemipteron. Julius Springer, Berlin.



## BOOK NOTICES

### Biology Afield

According to the opening paragraph in the preface, "This guide is designed to direct the student in the study of living organisms. It was written to provide a working method for Nature Study, Field Biology, and General Biology. The program of studies outlined here is obviously for Natural History Courses. It is the opinion of the writer that the cultural courses in Biology should be of this type, instead of the usual dissection courses which are primarily pre-professional in character."

This pocket-sized guide of 130 pages, written to accompany the author's textbook, entitled "The Living World" (reviewed in the *Ohio Jour. Sci.*, v. 37, p. 313), consists of 65 exercises of which 44 are on animals, 18 on plants, and one each on use of the microscope, plant and animal relationships, and directions for field collection, the latter of which consists almost entirely of a key to the Phyla and Classes of animals. With the exception of a chapter on the fauna of the seashore, the book deals with land and freshwater plants and animals. A three-page chart on where to collect and how to care for animals is very useful. Microscopic plants and animals are included (except for occasional statements the Protozoa were not included in "The Living World"); the nematodes and mammals are omitted. Animal ecology is represented by a number of chapters on surveys, environmental factors, and animal reactions. Efforts to illustrate interrelationships of animals are few. The section on botany covers the plant kingdom briefly, concerning itself mainly with morphology and classification.

The book contains many excellent suggestions and clearly delineates objectives. Directions concerning pursuit of the above are short. Accurate and integrated observation of living things in the field with precise and conservative interpretation, in this reviewer's opinion, is not sufficiently stressed. This laboratory and field guide may be used with distinct advantage over manuals consisting only of directions to laboratory exercises of dissections and drawings.—*C. Venard.*

**A Laboratory and Field Guide to Biology**, by Samuel H. Williams. xxv + 130 pp. New York, the Macmillan Co., 1938. \$1.25.

### Life and Its Origin

After many years of considering the question of the origin of life this author presents a lucid and carefully reasoned summary of the inferences he has drawn from investigations made by astronomers, technicologists, geologists, bio-chemists and others working in related fields. In the first three chapters the ideas of the spontaneous generation of living organisms "all at once," of the eternity of life, and of the dissemination of life by spores carried in cosmic dust are critically reviewed and rejected. The next three chapters are devoted to the evidence of a primary formation of organic substances on our planet, and of the further evolution of these substances previous to the origin of living systems. It is from these three chapters that the biologist will obtain the most useful data. A few of the conclusions reached by the author are indicated.

During the cooling of the earth after its separation from the sun as a molten mass of vapor, carbon and nitrogen first appeared upon its surface in a reduced state as metal carbides, metal nitrides and cyanamides which upon contact with the superheated aqueous vapor of the earth's atmosphere became the source of hydrocarbons and ammonia. Through oxidation-reduction reactions with the hydrogen and hydroxyl components of water these hydrocarbons and ammonia became the forerunners of a great variety of organic derivatives (alcohols, aldehydes, ketones, organic acids, amides, amines, etc.). Oxygen was retained at the earth's surface in combination with metals and in the atmosphere in com-

bination with hydrogen as superheated aqueous vapor. Molecular oxygen and carbon dioxide in our present-day atmosphere were formed secondarily and at a much later epoch, as a result of the activity of living organisms.

From the time when the primary oceans came into being, the environment in which organic compounds existed resembled our own so closely, that further transformations and evolution of organic compounds both previous to and after the origin of living systems may be safely surmised on the basis of three principal reaction types, "First, *condensation*, i. e., the lengthening of the carbon chain, and the reverse process of splitting the chains between two adjacent carbon atoms; second, *polymerization*, i. e., the union between two organic molecules through an atom of oxygen or nitrogen, and *hydrolysis*, the reverse process of splitting up such unions; and third, the process of *oxidation* with its invariable accompaniment of reduction." The last sentence is quoted directly because of the peculiar use of the terms condensation and polymerization.

Some of these organic compounds were colloidal in nature. When mixed together they may have become partially dehydrated and formed droplets of semi-liquid colloidal gels, or coazervates, which became separated from the solvent medium by a more or less distinct membrane. Such coazervates of organic matter in the archaic oceans became isolated centers of further evolution. Each coazervate droplet because of differences in composition and internal organization had a certain degree of individuality. Its further fate was now determined not only by the conditions of the external medium but also by its own internal physico-chemical structure. The entrance of materials from the external medium might result in destruction of the coazervate droplet or in its growth and evolution through further transformation in composition and internal organization. Coordination of internal processes would also be necessary to its continued existence. This coordination became increasingly complex with the evolution of dependent systems of enzymes. Given a sufficiently long period of time the origins of living systems from such coazervates merely represent definite mileposts along this historic road of the evolution of matter. The further evolution of living organisms is fundamentally nothing more than the addition of some links in an endless chain of transformations of matter. The first organisms were dependent upon the already formed organic matter as a source of food. Pigmentation and the manufacture of food by pigmented plants radically modified all the hitherto existing relationships and made possible the continued existence of organisms upon the earth.

The chief value of the book lies in the assemblage of a wealth of related experimental data within a single volume and the brilliant thought provoking way in which the author has organized these data and inferences. A bibliography limited largely to papers from Continental Europe is appended.—*H. C. Sampson.*

**The Origin of Life**, by A. I. Oparin, translated with annotations by Sergius Morgulis. New York, the Macmillan Co., 1938. \$2.75.

---

### Troubled Minds

This book is primarily descriptive. Well selected case reports give vivid pictures of a very wide range of mental deviates: the psychopathic, the psychoneurotic, and all the borderline cases of mental aberration found outside of mental hospitals, as well as those that can be classed definitely as psychotic. To present these descriptions "in simple terms and to state some original theories concerning the nature of these disorders" is the author's avowed purpose. For him, nervous and mental illnesses are "quantitative rather than qualitative disturbances; they are intrinsic disorders rather than extrinsic disorders; they are pathological exaggerations of the patient's native propensities." These propensities are fundamentally physiological. The basis for the psychoneuroses, and to a considerable degree for other disorders is found in the positive and negative physiological reactions of the organism. We react to a stimulus or *from* a stimulus. "A child runs from a barking dog to his mother." These "*from-reactions*" and "*to-reactions*" are fundamental for the psychopath as for the normal person.

Support of this physiological theory lies in illustration rather than argument. Nor are the arguments of those holding other theories answered. The theories of

different schools of psychoanalysis, for example, are not discussed. Their extensive vocabulary with its theoretical implications is practically ignored. "Psychocatharsis" and "psycho-genesis" appear in the glossary but not in the index. The long procession of patients lined up for clinical evidence have few "complexes" or parent "fixations." The author's physiological theory does not exclude, however, the usual distinctions between organic and functional psychopathology.

It is generally admitted that we should develop a program of public mental hygiene, as we have done in the field of public health. People must learn to look at mental disorders as objectively as they look at physical injury or illness without any feeling that there is any disgrace or shame involved. This book should be helpful in that direction.

The last chapter discusses the role of the patient in his own therapy. Why not one chapter at least on the responsibility of the parent, the teacher, and the physician in general practice? Some explicit discussion along this line would not only have indicated the constructive thinking necessary for a forward-looking program of mental hygiene but would have prevented the mistaken interpretation of the author's meaning which will lead some readers to find his theories fatalistic. "An individual's nervous disorders are related to his natural make-up; they do not emanate from external sources." "Whatever may be one's personal ambitions, he must live within his biological limitations." Yes, the patient is the patient, to be sure. But did he not have a father and a mother, go to school, and live in a social order? Perhaps he married, had friends, and worked for some employer. Can the problem be only that of an individual organism with a certain "make-up"?

—F. N. Maxfield.

**The Troubled Mind**, by C. S. Bleumel. xi+520 pp. Baltimore, The Williams and Wilkins Co., 1938. \$3.50.

---

### Vitamins Painlessly Administered

In 1935 Jennie Gregory published an interesting compilation of charts and diagrams summarizing the elementary facts in the field of endocrinology, which she called *The A B C of the Endocrines*. That little volume seems to have met with considerable success and now Miss Gregory has applied the same method to the field of the vitamins. In an attractively gotten up volume of less than one hundred pages she tells graphically and without the use of any continuous text, the story of the development of nutritional research and vitamin theory and then proceeds to give a surprisingly complete account of the occurrence, nature and physiological functions of the various vitamins. There is also included a graphic exposition of experimental methods and general vitamin relationships. The nature of the method employed prevents the book from being more than an outline of the subject, but an excellent bibliography is included from which those who are interested may obtain more complete information. The value of the book is also enhanced by the glossary in which more than one hundred fifty terms are defined.—Fred A. Hitchcock.

**The A B C of Vitamins**, by Jennie Gregory. xii+93 pp. Baltimore, The Williams and Wilkins Company, 1938. \$3.00.

---

### Physical Principles

In the revision of this excellent textbook of general physics, Dr. Smith has strengthened its many fundamental and outstanding features and has added important material in modern physics and an interesting chapter on nuclear physics.

The book is widely used as a general text in the subject for class room work, but it merits attention by workers in allied sciences who may desire (1) to review important principles of physics; (2) to make concrete application of physics to the solution of simple fundamental problems requiring definite answers in specified units (note the large number of solved problems in all fundamental phases of elementary physics); (3) to make a fair beginning in the application of physics to the allied biological fields (note the numerous applications to related phenomena in biology, physiology and agriculture); (4) to review and clarify fundamental

concepts in the field of light and radiant energy (this phase of physics is particularly well done and the importance of it in allied fields is well recognized by the author); (5) to become better informed concerning the recent advances in modern and nuclear physics (most of the new important concepts of matter, radiation, and atomic structure are treated in a not too technical way in the chapters on spectra and nuclear physics).—*C. W. Jarvis.*

**Elements of Physics**, by Alpheus W. Smith, 4th edition. xix+790 pp. New York, The McGraw Hill Co., 1938. \$3.75.

---

### Avian Ecology

In summing up a portion of the results of an eight-year study of the Song Sparrow made at Columbus, the author of this volume has produced a work which will prove quite indispensable to those interested in the life history and ecology of birds. It would be difficult or impossible to name any other single source which contains a comparable amount of information concerning a North American bird. The salient facts in the life history of the Song Sparrow are reviewed briefly but the larger part of the work is devoted to a study of a population rather than of the individual bird. Among the outstanding chapters are those which treat of the migratory status, survival and length of life, relations with the Cowbird, and effects of temperature on migration and on the breeding cycle.

The work is admirably organized. The author presents a wealth of original data clearly and concisely, with frequent but judicious use of tables and diagrams in the text. Each chapter is summarized separately. The interpretation of the data owes much of its authority to the author's command of pertinent literature. The techniques of the study are explained in an appendix which should be of especial value to the student. There is a comprehensive bibliography and an adequate index.

This book may be safely recommended not only to the student of birds but also to those interested in the broader fields of ecology and animal behavior. Furthermore it furnishes an outstanding example of a worth-while scientific study accomplished without recourse to elaborate equipment and without subsidy.

—*C. F. Walker.*

**Studies in the Life History of the Song Sparrow. 1. A Population Study of the Song Sparrow**, by Margaret M. Nice. Transactions of the Linnean Society of New York, Vol. IV, April, 1937, vi+247 pp. \$1.50.

---

### Log of a Bird-banding Station

This book is a record of eight years of bird-banding (1923 to 1930) by the author and her husband on their 30-acre suburban estate, Tanager Hill, on the shores of Lake Minnetonka about 15 miles west of Minneapolis. Most of the book (pp. 7-208) consists of the 8-year banding record, written in the form of a diary of the experiences operating the station; the remainder of the book is a brief introduction and summary.

The book is based on a great deal of detailed data, the record of banding 18,024 birds of 97 species, with 21,799 repeats and 626 returns. These data seem rather inadequately summarized. The summary consists of two sections, "Analysis of Return and Recovery Records," and "Appendix (Technical Data)." The first is a very interesting but brief summary of the records of 26 of the 97 species, and the second contains tables of the station returns and recoveries. These two sections are poorly edited, as there are many discrepancies in the figures given in the two sections, and several typographical errors. Such general information of interest to ornithologists and bird banders as the types of traps used, bait, location of traps, success of different traps, effect of predators, and the like, are mentioned through the log, but are not included in the summary.

The book contains a table of contents, but no index. There are 19 illustrations, including 17 photographs (mostly from the U. S. Biological Survey), 1 graph (more

would have added to the value of the book), and 1 map of Tanager Hill. Three of the photographs show traps, a drop trap, house trap, and sparrow trap.

This book is "published for the enjoyment and information of ornithologists, bird banders and all bird lovers," and to a considerable extent fulfills these aims. Though its style is that of a diary, it holds the reader's interest very well, as the descriptions of Tanager Hill and the experiences of bird-banding are vivid and fascinating. The ornithologist and bird bander will find much of value in this book. As the author observes, Tanager Hill is only one of thousands of rural homes that offer opportunities for bird-banding and fascinating adventures with birds, and there seems to be no reason why many other people might not have experiences like those described in this book.—*D. J. Borror*.

**The Log of Tanager Hill**, by Marie Andrews Commons. xvii+244 pp. Baltimore, The Williams and Wilkins Co., 1938. \$2.50.

---

### Zoology

With the increase in emphasis upon science in everyday living has come a demand for courses in science which are not so technical: courses designed for the layman in the field *not* specifically for the majors in a given area. Dr. Wieman of the University of Cincinnati has made a real contribution towards the fulfillment of this demand in the third edition of the textbook "General Zoology." The book is comprehensive but not exhaustive. The relationship of Zoology to everyday living is well handled. Body structures are considered in relation to their function, not as separate morphological phenomena. Familiar animals serve as examples but constant reference is made to the human body. Animals are considered in relation to their environment with some mention (though not too extensive) of the interaction of one upon the other. The author says a great deal in a short space. Although concentrated, the careful average student should be able to handle the matter readily. Only ninety pages are devoted to a discussion of the Animal Kingdom, which many may consider too few, but characteristics and examples of the main groups are given and tests have shown that the details of morphology are not long remembered by the general student in any event.—*Paul E. Schaefer*.

**General Zoology**, by H. L. Wieman. x+497 pp. New York, McGraw-Hill Book Company, Inc., 1938. \$3.50.

---

### Five Sisters

An account of the most popular quintet in the world, told in a simple and interesting manner, this book of 205 pages is amply illustrated with photographs of the quints taken at different ages and engaging in various activities. Comprehensive descriptions of the living arrangements, the evidences of identity of the quints, and their individual physical, intellectual and personality traits are rendered. Diagrams and detailed plans of the Dafoe hospital and the play grounds are shown, and the daily routines are described in detail.

Perhaps pedagogues are more prone than others, consciously or unconsciously, to allow their own viewpoints to influence what should be unbiased accounts. At any rate, there seems to be a tendency for the author to go to undue lengths in a rather defensive explanation of the various mental test scores of the quints, and on the other hand to draw extensive conclusions from superficial tests of personality. A curious inconsistency appears in Chapter 4; on page 49, the statement, "but even though twins emerge from a single egg, the division of the cells is so complex that there is still a chance that one part may have a few hereditary elements different from the other," and on page 64, the statement, "it must be considered that they have a common heredity, that structurally they are alike."

The Five Sisters is a book which should be in the possession of those interested in the Dionne quintuplets, and is a valuable reference for students of the nature-nurture problem.—*D. C. Rife*.

**The Five Sisters**, by Wm. E. Blatz. 205 pp. New York, William Morrow & Co., 1938. \$2.50.

### Our Amazing Earth

Devoid of jargon, yet safely accurate, is "Our Amazing Earth," the latest addition among recent books placing emphasis upon a popular treatment of the science of geology and related subjects. The book is welcomed by those teachers who have recently been surveying the problem and need for broader and more general public education in the science of the planet of man. It should be eagerly grasped by the average layman.

The author's logical arrangement starts with a portrayal of the earth's astronomical relations, followed by speculation as to the earth's origin and age. Next are treated the materials of the earth's crust and their arrangement, and then a discussion of the natural agents and processes which operate upon the earth's surface in the development of our ever-changing landscape. Finally, for those readers who are inquisitive as to the earth's long past, are a few short chapters giving glimpses of geologic history.

The author and publishers are to be commended for their many exceptional halftone illustrations and well chosen diagrams.—*Paris B. Stockdale.*

**Our Amazing Earth**, by Carroll Lane Fenton. xvii+346 pp. New York, Doubleday, Doran & Company, Inc., 1938. \$4.50.

---

### Laboratory Arts

This is the first book in English attempting to cover such a wide range of subjects that has yet come to this reviewer's attention. While there have been works each on one of the separate subjects covered in the many chapters of "Procedures in Experimental Physics," no one has attempted to put into one volume the wealth of material that the present author uses.

The usefulness of the techniques described is not limited to the physical laboratory, and every scientific worker should be more or less familiar with them or know where to find them described. To be sure no book knowledge can be a substitute for skill in manipulation, but the painstaking descriptions of several of the processes will serve as starting points for anyone wishing to become more familiar with them.

Most of the modern physical methods and techniques developed in the past few years are adequately described. The construction and use of Geiger-Muller counters, of vacuum thermopiles, of quartz fibres are all discussed, while the first chapter is a course in elementary glass-blowing. Photographic methods and testing of optical systems also receive attention, as well as the construction of special types of burners and furnaces.

One remarkable feature of the book is the entire absence of photographs. All illustrations are pen-and-ink drawings by an accomplished artist and some of them are so carefully made that they could serve as working drawings. The only adverse criticism that could be made is with respect to the graphs, where plus signs are used to indicate crossing positions of abscissa and ordinate lines. To the physicist this mark would indicate an experimental point, and it is disconcerting at first to see curves passing among a group of them without getting near any of them.

—*J. B. Green.*

**Procedures in Experimental Physics**, by Strong. x+642 pp. New York, Prentice-Hall, 1938. \$5.00.

---

### Political Arithmetic

The distinguished professor of social biology at the University of London, Dr. Lancelot Hogben, has recently accepted a post at Aberdeen. The present volume appears to be in the nature of a summary of the work carried on in social biology, particularly in the field of population enquiries, during his tenure at London. Some of the chapters are reprinted from journals; about half of the material is presented for the first time. Following an introduction by Hogben, chapters on various aspects of fertility are offered by Enid Charles, Kuczynski, Glass and Moshinsky. The second part of the volume, again following an introduction by

Hogben, contains chapters on various aspects of education and opportunity in the British Empire. The final chapter is a study of the distribution of the blood groups and its bearing on the concept of race. New contributors in this part of the volume are J. Gray and David Morgan. The book is valuable not so much for the factual material it contains as for the methods it demonstrates for attacking problems of social biology. There are many graphs and tables, and the book is beautifully bound.—*L. H. S.*

**Political Arithmetic**, edited by Lancelot Hogben. 531 pp. New York, The Macmillan Co., 1938. \$9.00.

---

### Practical Bacteriology

A useful addition to the library of any bacteriologist is this recently revised handbook which bridges the gap between the laboratory manual and the text book, a gap the laboratory instructor usually seeks to fill by discussion. The book is divided into three sections: Part I is general and introductory, Part II deals with bacteriological technique, and Part III with pathogenic micro-organisms and with bacteriological diagnosis. There is a particularly excellent discussion of the microscope. Although the newer system of classification, taken from Bergey's *Manual of Determinative Bacteriology*, is given in the first part of the book, the authors, unfortunately, use the older classification throughout their discussions. This may lead to some confusion. Bacteriologists will find the book an excellent ready reference and a valuable supplement to the general tests.—*J. M. Birkeland.*

**Practical Bacteriology**, by J. T. Mackie and J. E. McCartney. 5th ed., xi+586 pp. Baltimore, William Wood and Co., 1938. \$4.00.

---

### Bacteriology

This pocket-size volume of less than three hundred pages is one of a series of Students Aids "specially designed to assist students in grouping and committing to memory the subjects upon which they are to be examined, yet offering the General Practitioner an invaluable means of brushing up." The late W. Partridge and H. W. Scott-Wilson, who is responsible for the current revision, have presented clearly, concisely, and accurately factual material covering the whole field of bacteriology. They have accompanied it with sufficient description and explanation so that the book is a ready and usable reference to the student in bacteriology and to workers in fields allied to bacteriology.—*J. M. Birkeland.*

**Aids to Bacteriology**, by W. Partridge and H. W. Scott-Wilson. vii+300 pp. Baltimore, William Wood & Co., 1938. \$1.50.

---

### Science for Young People

The intrinsic interest of scientific developments and their applications is delightfully represented in this little book. Physics, chemistry, and biology are represented in the thirty brief chapters, each of which deals simply and intimately with a single topic such as "How chemical curiosities aid industry," "Wealth from the sea," "Farming on water," "Teaching wood new tricks," "Raincoats from test tubes," "Human electricity," "Harnessing time," and "Our enemy, noise." Written for young people, this book will prove thoroughly enjoyable to anyone who is interested in science. The author's information is accurate, and his style is most engaging. Large type and well chosen illustrations add to the attractiveness of the book.—*Harold Knauss.*

**The Magic Wand of Science**, by Eugene W. Nelson. 213 pages. New York, E. P. Dutton and Company, 1938. \$2.00.

# THE OHIO JOURNAL OF SCIENCE

---

VOL. XXXIX

MARCH, 1939

No. 2

---

## EXTRAORDINARY DEVELOPMENTS AT OR NEAR THE ENDS OF EVOLUTIONARY SERIES.

### STUDIES IN DETERMINATE EVOLUTION, XI\*

THE LATE JOHN H. SCHAFFNER

When the taxonomic groups of plants are arranged in proper phylogenetic series in agreement with their advancement in complexity of reaction systems, a remarkable situation becomes evident that could not be recognized so long as taxonomy was developed along the lines of the old, haphazard teleological hypothesis of origins. It is found that at or near the ends of many orthogenetic series, especially the higher ones, one frequently meets with very unusual, peculiar, or extraordinary characters and complexities which are not in evidence or only very rarely so in the lower levels of the series. Not only are these extreme developments unusual and particular but they are frequently bizarre and grotesque, each series usually having some characteristic structures or reactions not evolved in other series, even though the general evolutionary developments have been essentially similar. Curiously enough these extraordinary characters were formerly often taken to indicate primitiveness; as for example, *Zea mays* L. was put at the bottom of the grass series although it has a most remarkable array of unique and highly evolved characters.

When one studies a group of organisms from the phylogenetic point of view, it is always advisable to look for these unusual characters near the supposed limits of the main lines and near the ends of the various subordinate series. It is impossible at the present time to form an adequate conception of the cause or causes of this remarkable biological phenomenon, but it appears to be associated with highly specialized and com-

---

\*Papers from the Department of Botany, The Ohio State University, No. 409.



plex aggregations of hereditary potentialities in the evolved protoplast. When the protoplast becomes filled, so to speak, with a great aggregation of hereditary potentialities these extraordinary mutations seem to occur very frequently when compared with the more uniform accumulation of characters appearing at the lower levels of the phyletic series.

In the present study a general view of some of these extraordinary forms is given, the examples being taken mostly from the higher, vascular plants. A few, however, are from the lower plant series in which remarkable structures are by no means absent.

Among the most bizarre forms are a number of advanced gastromycetous fungi; like *Dictyophora phalloides* Desv. This is a mushroom with a very fancy lace-like "petticoat." The lower true fungi are mostly composed of a loose, branching mycelium, which, although it may react to various stimuli as light, substratum, etc., seems to have only a very slight correlative interaction between the different mycelial branches. In the highest fungi, this property of unitary correlation between the hyphae becomes truly marvelous in the development of the fruiting body. The mycelial threads in their growth and branching weave patterns as astonishing in their complexity as a complicated tapestry. *Dictyophora phalloides* represents an extreme example of such reaction. It is difficult to believe that such a plant exists if one has never seen it. It has a pure white stipe, a cap of greenish color, and, as stated above, a white-lace-like petticoat, with polygonal and hexagonal meshes, suspended around the stipe below the spore-bearing body. It has, moreover, a most vile odor combined with its wonderful beauty of form and color.

There are various extreme culminations among the higher algal series. In the Characeae, or stoneworts, the species of *Chara* have very peculiar and complicated sex organs, especially the antheridium. The antheridium is spherical in shape and looks externally as if composed of solid tissue, but it is really a highly organized system of filaments with long branches coiled up in the inside, the individual cells of these filaments developing the spermatozoids. The antheridia are bright red in color in decided contrast to the nearby oogonia which are green, flask-shaped bodies covered with five spiral filaments. The sexual dimorphism of these gametangia in form, structure, and color is just as extreme, even though they develop side by side on the

same branch, as the sex difference in various birds and other higher animals, which has been ascribed by the teleological selectionists to the causative operation of "sexual selection," one or the other mate being supposed to have a preference for fancy colors and unique forms. As stated, in *Chara* the red antheridia and green oogonia are situated on the same individual, but similar differences in color and form of parts surrounding the sex organs are also found in species of *Polytrichum*, which are among the most highly evolved unisexual mosses. The relative dimorphism is just as great as between a hen and a rooster. The absurdity of the sexual selection hypothesis becomes evident when applied to these mosses which have neither eyes nor brains with which to make a choice of mates; but in spite of great numbers of such contradictory cases, the "sexual selection" delusion has not yet entirely disappeared from a certain type of biological mind.

Our living species of *Equisetum* represent the surviving culmination type of a great group of plants that appeared far down in the geological scale. All the living species of *Equisetum* show an unusual development in the peltate sporophylls and in having highly hygroscopic, coiling elaters attached at one side of the spores, produced by the spiral splitting of the outer wall of the tetraspores. Another extreme condition in most of the species is the extraordinary development of silex in the cell walls, especially in the epidermis. The highest species, *Equisetum arvense* L., is an extraordinary plant because it, with its near relatives, shows an extreme dimorphism of its vegetative and reproductive, aerial shoots. The vegetative shoot is green and much-branched and survives until late autumn while the reproductive shoot is without green color, is unbranched, and dies in a few days after coming out of the ground. Such extreme dimorphism of the entire shoots is exceedingly rare in the plant kingdom.

In the Polypodiaceae, which represent the highest, homosporous, leptosporangiate ferns, an extremely unique and perfected type of sporangium, capable of throwing the spores a short distance, has developed. The heterosporous water ferns are the most advanced types in the fern phylum and also exhibit a number of unusual developments. *Azolla caroliniana* Willd. is a tiny, free-floating plant which has attained the extreme limit of leaf arrangement, the alternate, two-ranked system. In its microsporangia it develops peculiar massulae,

each containing several microspores. On the surface of these massulae anchor-like processes or glochidia with septate stalks are borne. Comparable masses of microspores or pollen, but of a different structure, are found in some orchids and in milkweeds, both of which groups represent extreme developments in their phyletic lines. *Salvinia natans* (L.) Hoffm. has remarkably developed floating leaves which tend to keep the plant right side up and in addition finely dissected leaves having the appearance of roots dangling into the water. In the genera *Marsilea* and *Pilularia* highly specialized sporocarps are developed which discharge their sporangia and spores by emitting a gelatinous, elastic band or cord to which the sporangia are attached. All these characteristics are unique in the plant kingdom.

A very bizarre condition is present in the higher species of *Selaginella* which represent the most advanced stage in the living Lepidophyta. In these species, the closed vascular bundles, whose chief function is the transfer of water through the plant body, are situated in tubular cavities filled with air in the ground tissue of the stem. The bundles are suspended in the middle of the tubes by means of filaments of cells passing from the walls of the tubes to the surface of the bundles. Compared with the usual stem structure, this arrangement of the tissues certainly represents an extraordinary mechanism.

In passing from the Pteridophyta to the Gymnospermae, one discovers a pronounced advance in the complexity of the general reaction system of the cell. One is prepared to meet with odd developments as soon as one encounters the more highly evolved genera. Among the highest of the Taxodiaceae is *Taxodium distichum* (L.) Rich. which has among other remarkable features the development of large woody outgrowths or "cypress knees" from the roots and highly specialized, herbaceous, annually deciduous, feather-like dwarf branches. It also has decidedly ornamental markings on the outer surface of the carpels of the globular cone. *Sciadopitys verticillata* (Thumb.) S. & Z., another advanced type of the Taxodiaceae, is remarkable for its dwarf branches with long double needle leaves.

Among the Pinaceae, the genus *Pinus* contains the species with the most complicated reaction systems and with some very unusual structures. The peculiar combination of needle leaves (some as in *P. palustris* Mill. up to 16 or more inches long), deciduous dwarf branches, fission embryos with extraor-

dinary embryonic development, whorl of linear cotyledons, and in some species, as in *P. coulteri* D. Don. enormous, woody ovuliferous scales and zygomorphic cones, determines the pine as one of nature's most remarkable handiworks. In some species of the Juniperaceae, as in *Biota*, the oriental arborvitae, the embryogeny is even more peculiar than in the pines. The egg begins to develop about 40 embryos with long thread-like suspensors so that the whole group looks like a tiny mass of thread. A single one of these 40 fission embryos finally develops in the maturing seed. This represents about the extreme of embryo development, whether plant or animal, and appears in the highest family of the Pinales. In *Juniperus* one meets with an enormous branching ability in some species and a minute, colored, berry-like cone with carpels permanently fused at maturity and developing a single seed in the highest species. In *Taxus canadensis* Marsh., one of the culmination types of the Taxales, the peltate stamens come to the same general form as the sporophylls of *Equisetum*, which an extreme Darwinist might regard as a conclusive case of mimicry. The reduction of the carpellate flower to a single ovule on a vestigial carpel lacking a blade and the development of the bright red fleshy aril around the seed are also unusual and extreme developments.

The highest class of Gymnospermae, the Gnetales, contains one of the most bizarre plants in the plant kingdom. *Welwitschia mirabilis* Hook. f. of the South-west African desert has but two great, ribbon-like, foliage leaves that grow from the base during the entire life of the individual and finally split into numerous narrow segments. The terminal bud becomes determinate when these first two foliage leaves have been produced and only reproductive buds are produced later. This species has a large number of other extraordinary characteristics which tend to make it one of the most remarkable plants in the world.

The flowering plants, or Anthophyta, are the highest and most complex of the plant phyla. They have a complement of 100 or more fundamental potentialities common to all the species of the many phyletic lines or series into which this greatest of plant groups has segregated. Thus unusually large numbers of extraordinary structures have evolved. Only a few of these can be mentioned here to illustrate the general principle. At the top of the Helobiae, the lowest subclass of monocotyls, is that extremely interesting species, *Vallisneria spiralis* L. It is an aquatic plant with long ribbon-like leaves, has the

carpellate flower on a very long spirally coiled peduncle which reaches the surface and after pollination the fruit is drawn down by this coiling peduncle and ripens under the water. The staminate inflorescence has a short peduncle with numerous minute flowers about the size of a pin head. These flowers are abscised and float on the surface and their dehiscing stamens thus come in contact with the receptive stigmas of the carpellate flowers. It is difficult to imagine a more unique method of pollination.

The Araceae and Lemnaceae are advanced families of the Spadiciflorae which also include the palms and Pandanales. One of the extraordinary species is *Alocasia odora* (Roxb.) C. Koch, which has a powerfully odoriferous organ at the top of the spadix and a spathe that is separated in the middle by the development of a corky layer which finally causes the outer end to wither away while the lower end becomes thick and fleshy, forming a tight compartment around the zone of carpellate flowers. This bottle-like structure fills with water secreted on the inside in which the fruit develops. A number of related species have similar characteristics. Among the duckweeds (Lemnaceae) is the genus *Wolffia* which contains the smallest species of seed plants. It has a minute egg-shaped body, which floats on the surface. Its lack of roots and leaves, together with other extreme simplifications, is probably caused by a large number of acquired, inhibitory, hereditary factors. It possesses an extreme ability for vegetative multiplication, the joints separating from each other as rapidly as they are produced. This vegetative multiplication proceeds at such an enormous rate that myriads of individuals may be produced in a favorable season. Dr. L. E. Hicks found that in the drought year of 1933, a single acre in Buckeye Lake in Ohio contained a thousand times as many individual plants of *Wolffia punctata* Griseb. as there are human beings in the whole world.

The Glumiflorae are a rather highly specialized group of plants, the Cyperaceae a lower and the Gramniaceae a higher family of the group. Among the Cyperaceae an extreme development is found in *Eriophorum viridicarinatum* (Engelm.) Fern. and related species in which the ordinary perianth is replaced by a great number of elongated bristles, much like the pappus of many composites. The genus *Carex* has an odd sack-like structure around the ovulary which is not present in any of the lower sedge genera nor in any of the grasses. In such advanced species as the hop sedge (*Carex lupulina* Muhl.) the style is

elongated and bent at the lower end into a peculiar double curve. The more advanced tribes of grasses show many exceedingly interesting developments. In the Agrostideae, *Stipa pennata* L. has a fruit with a sharp point at the base and a large twisted and bent awn with a flexible, plume-like end about 12 inches long. Among the oddities in the Panicatae may be mentioned the species of *Cenchrus*, or sandburs, in which the pairs of spikelets are enclosed in a bur representing a cortical outgrowth of tissue covered with rigid, retrosely barbed prickles. In the highest tribe, the Andropogoneae, there are many remarkable plants. Teosinte (*Euchlaena mexicana* Schrad.) has husks covering the carpellate inflorescence, long hair-like styles or silks, and a most peculiar, bony and polished, box-like structure, composed of a rachis joint and an outer empty glume serving as a lid. This box contains the carpellate spikelet and mature grain. The most advanced and extraordinary grass is the Indian corn (*Zea mays* L.) with prominent prop-roots, extreme dimorphism between carpellate and staminate inflorescences, the ear and its cob enclosed in a highly evolved husk, the very long styles or silks together with very long, rapidly-growing pollen tubes, and finally with the highly developed caryopsis or grain containing in different varieties a complex assortment of endosperms of various colors—including flint, waxy, sugary, flour, starchy (dent), and pop varieties. The evolution of the grasses has culminated in a profoundly unique and useful plant.

Near the upper levels of the Liliales are the rushes and here again one finds a unique structure in some of the higher species, as in *Juncus militaris* Bigel. and *J. acuminatus* Mx., in which the leaf blades have a series of transverse diaphragms. In the Tillandsiaceae, *Dendropogon usneoides* (L.) Raf., the Spanish-moss, is an extraordinary plant in many respects. It is one of the most extreme types of epiphytic plants. The stem and very slender leaves are closely covered with translucent, silvery-scurfy, ovate-lanceolate scales, peltately attached, with an oval somewhat glandular area above the point of attachment. The stem is very slender and spirally coiled and flexuous, hanging in clustered festoons from the branches of trees. The leaves have also attained the determinate limit in arrangement, being alternate two-ranked. A very remarkable structure is shown by the very long funiculus of the seed, which splits up into a cluster of fine threads. In the Eriocaulaceae, the most extreme family of the Liliales, the flowers are minute and are collected into

disk-like heads which look much like the heads of some Composites. Some species, as *Syngonanthus anthemidiflorus* (Bong.) Ruhl., have enlarged, spreading, involucre bracts causing the inflorescence to simulate an *Anthemis* belonging to the sunflower family. The Eriocaulaceae also contain various species having their corollas transformed to a ring of hairs between the calyx and gynecium. One of the most extreme species with this peculiarity is *Lachnocaulon anceps* (Walt.) Morong.

In the Iridaceae there is a most remarkable flattening, in some species, of the leaves and aerial stem. This flattening is extreme in some species of *Sisyrinchium* and *Marica*. Species of *Iris* show extreme oddities in the petaloid stigmas and hairy crests on the sepals. Some species also have an extreme development of the solid, epigynous hypanthium, a rare structure in the flowering plants. In the two higher families Cannaceae and Marantaceae, of the Scitaminales, the flower is of the zygomorphic type but has in addition developed an inequilateral form, having thus only a half-fertile stamen, the other half being petaloid.

The Orchidaceae represent the most advanced plants among the Monocotylae with the most complicated accumulation of hereditary potentialities. In this family there are many odd and remarkable structures in the flowers, leaves and roots. An unusual development appears in some genera. The pollen is organized into definite bodies or pollinia which are more or less pear-shaped and may have a little stalk or caulicle with a viscid disk or gland at the base. These disks stick to insects visiting the flowers and the pollen is thus carried about. Advanced types of pollinia are found in the following genera: *Orchis*, *Galeorchis*, *Lysias*, *Tipularia*, *Coeloglossum*, *Corymbis*, *Ponthieva*, *Stanhopea*, and many others.

The Dicotyls number at least four times as many species as the Monocotyls and show a correspondingly larger number of extreme and peculiar developments. On a rather advanced level of the Thalamiflorae are the species of the genus *Euphorbia*, which is now usually divided into a considerable number of smaller genera. The flower cluster is a cyathium which in some cases simulates a single flower in appearance very closely, as for example the cyathium of *Tithymalopsis corollata* (L.) Kl. & Garcke. The species of *Chamaesyce* have opposite two-ranked leaves and alternate two-ranked branches, a very unusual culmination type but also present in the related Zygophyllaceae as

in *Tribulus terrestris* L. A most extreme type of cyathium is present in *Pedilanthus tithymaloides* (L.) Poit. Some of the fleshy forms of Euphorbia have bodies that mimic in a remarkable manner the forms and characteristics of the American Cactaceae, including the spines and loss of leaves. Among the extreme types are *Euphorbia obesa* Hook. f. and *E. meloformis* Ait. with bodies more or less spherical in shape.

Near the end of the Thalamiflorae are the blue violets with their showy flowers on very long peduncles that produce little or no seed; but the same individuals develop cleistogamous, apetalous flowers and these are very fertile, producing seed abundantly. In spite of this and numerous somewhat similar cases, some botanists still continue the old delusion that showy flowers are the result of natural selection. In the not distantly related passion-flower (*Passiflora*) there is a special structure developed in connection with the corolla, the so-called corona.

In the Piperaceae, whose systematic position is somewhat doubtful but which represent an advanced condition of flower and inflorescence, we meet with that unique phenomenon in the angiosperms, the 16-celled embryo-sac, present in some species of *Peperomia*. In these female gametophytes multiple fusion of numerous embryo-sac nuclei takes place to produce the primary endosperm nucleus. In one species fourteen nuclei are known to fuse. If a sperm nucleus is also involved, the following endosperm nuclei, numbering about 40, would have a 15-ploid chromosome constitution instead of the usual triploid condition.

The milkweeds belong near the end of the series of Polemoniales. in the Tubiflorae. These plants have evolved a remarkable specialization of the andrecium. The pollen of the milkweeds (*Asclepias* and other genera) is massed together in pollinia which remind one of the massulae in the microsporangia of *Azolla* and the pollinia of orchids. In the milkweeds the two sacs of pollen are joined together by a peculiar connecting piece with a slit in it, in which the foot or proboscis of the insect is caught and thus the pollinia are pulled out of the anthers and carried away. This highly elaborated mechanism is so inefficient that usually in our common milkweed (*Asclepias syriaca* L.), even in the presence of abundant swarms of pollinating insects, less than one in a hundred flowers is ever properly pollinated. The Asclepiadaceae also contain some rather extreme forms with succulent stems and minute leaves, comparable to those of the Euphorbias, cacti, Mesembrianthemaceae, and a few composites.



Near the top of the Scrophulariales are the bladderworts (*Utricularia*) which bear on their leaves, under the water, little bladders which have been designated as the most remarkable structures in the plant kingdom, comparable somewhat to the complex organs of the higher animals. One of the most perfect type is found in *Utricularia macrorhiza* Le Conte. These little bladders are provided with entangling and irritable hairs around the mouth and with a trap-door on the inside. The bladders are contracted in the resting condition and when an unlucky little plant or animal swims up and accidentally comes in contact with the irritable hairs, the bladder expands suddenly and the victim is sucked in through the mouth to be definitely imprisoned by the closed trap-door.

In the closely related order, the Lamiales, the highest family is represented by the Lamiaceae and one of its extreme genera is *Salvia*. The species of *Salvia* have evolved a most remarkable andrecium which in the more advanced forms consists of two stamens with only one half of the anther fertile, the other half being developed into a long sterile lever attached to the stamen filament by a movable joint. The whole apparatus represents a very ingenious pollen brush which brushes the back of any insect seeking nectar in the base of the flower. This is without doubt a useful mechanism and works efficiently but other species of the mint family which have no such highly elaborated mechanism for pollination are just as successful as the sage.

Among the Amentiferae, which represent an extreme evolutionary series, apparently distantly related to the lower Calcyflorae, one again finds numerous unusual characteristics. Among these may be mentioned the fruit of the common fig, (*Ficus carica* L.) the woody cup below the acorn of the oaks (*Quercus*), and somewhat similar developments in related genera. The cone-like fruit of alder (*Alnus*) is also remarkable and somewhat similar developments are found in certain Proteaceae. Probably the most unusual manifestation in this highly advanced subclass is the presence of chalazogamy in various genera, as in *Juglans*, *Carya*, *Casuarina*, *Corylus*, *Betula*, etc., in which the pollen-tube, instead of passing along the usual route through the micropyle, penetrates through the base of the ovule. This action indicates that the pollen-tubes have attained the extreme of parasitic ability.

The Myrtiflorae also contain highly evolved groups and one can easily find odd and unique structures among them. In the

cacti are developed many unusual forms of body and spine. Some of the forms are very extreme and simulate the bodies of Euphorbias. Some species of *Opuntia* have very sharp spines with retrorse barbs which, however, are covered with a papery sheath. This sheath develops an abscission zone at the base and is thus easily removed from the spine.

Among the Cucurbitaceae are various extraordinary fruits, such as the squirting cucumber (*Ecballium elaterium* (L.) A. Rich.), watermelon (*Citrullus*), etc. There is an authentic record of a watermelon attaining the enormous weight of 183 lbs. In this region of the plant kingdom also occurs that remarkable monstrosity, the largest flower in the world, produced on a parasitic plant with inconspicuous body and without green leaves, *Rafflesia arnoldi* R. Br. (Rafflesiaceae). This flower weighs about fifteen pounds and measures a yard across. The petals are about a foot in length and vary in thickness from three-fourths of an inch in the thickest part to one-fourth of an inch in the thinnest part. There are several other species of *Rafflesia* with most remarkable flowers.

Another family of this subclass is the Mesembrianthemaceae which has a number of genera with extremely unique body forms, some of which are supposed by teleologists to simulate pebbles, as in *Mesembrianthemum ficiforme* Haw. Extreme forms of plant body are present in the genera *Lithops*, *Frithia*, *Fenestraria*, etc. The species of *Fenestraria* have "windows" at their leaf-tips which project out of the ground. The compact forms of these extreme Mesembrianthemums suggest the somewhat similar forms appearing in many species of cacti which seem to be distantly related to them.

The mangrove (*Rhizophora mangle* L.) belonging to the Rhizophoraceae, has several extreme characteristics. The seed sprouts in the fruit on the tree and when the embryo is quite large it drops down into the mud or water. The mangrove also has a remarkable, aerial root system which forms a complex branching prop about the base of the trunk.

Among the Caprifoliaceae are a number of species in various genera that produce twin flowers, as in some species of *Lonicera*, *Linnea*, and *Kolkwitzia*. The latter is also bizarre in producing an elongated neck between the ovulary and calyx which spreads out horizontally somewhat like the pappus bristles of some composites.

In advanced Angiospermae with complex and specialized

complements of hereditary factors, the sequence of differentiation in determinate shoots, as in the inflorescence axis or the flower receptacle, is often changed from the primitive type, where the differentiation gradient follows the order of the cell lineage, to a new sequence. In *Campanula*, as in *C. americana* L. and other species, the spicate flower cluster begins to bloom at the base in the usual way but at the same time the very tip flower also comes into bloom. The remaining flowers of the spike develop in the normal sequence from the lower level to the terminal flower which has passed its blooming period for some time. In the elongated head of the wild teasel, *Dipsacus sylvestris* Huds., the blooming begins in the middle and proceeds toward the base and apex at the same time. A similar sequence is followed in the blooming of the ear and tassel of Indian Corn, *Zea mays* L. In various types of advanced flower clusters, as in *Lacinaria* and in *Nabalus asper* (Mx.) T. & G., the heads begin to develop and bloom at the tip of the stem and continue downward to the base. Many such odd gradients develop in various advanced groups.

The highest family of plants is, without question, the Cichoriaceae. Here the genus *Tragopogon*, to which the common salsify belongs, has evolved a truly wonderful pappus which forms a large parachute on the fruit. This parachute closes up in wet weather and expands when dry. It also has an abscission layer by means of which the plane of the parachute is finally separated from the long stalk that connects it with the achene. In the common dandelion (*Taraxacum officinale* Weber) there is a similar, although less elaborated, parachute, and in addition a much more remarkable development. The plant has evolved diploid parthenogenesis, or virgin birth, for all of its offspring. All the seeds are developed without fertilization and thus the pollen and pollination by means of visiting bees or other insects are of no use whatever to the plant. In addition to these two extraordinary characteristics, the dandelion has the unusual ability to split into new individuals vertically after a certain age is attained and to be rejuvenated during the process, so that after the splitting the juvenile type of leaves is again produced. It is also able to produce a new individual from any little scrap of the root. The dandelion not only has these extreme characteristics but also has one of the most complex if not the most complex complement of general and special hereditary potentialities of any plant in the plant kingdom.

The same principle of the evolution of extraordinary characters in the higher levels is also operative in the various animal series. In the insects, for example, the polymorphic development of members of colonies of ants, wasps, and bees and their instinctive social reactions are extraordinary characteristics. The unusual nest-building abilities of many of the higher birds as compared with the more primitive species or with the reptiles also represent the same evolutionary manifestation.

Man himself is the most remarkable example of the working out of this principle of extraordinary developments at or near the ends of phylogenetic lines, and thus occupies a most unique position among all living things. Man represents the determinate limit of many evolutionary, progressive series. He has attained the limit in his perfectly erect position. He has extreme specialization of fore and hind limbs, suitable for very different activities. The development of the arms, and especially of the hands, of man into remarkably mobile instruments makes them fit alike for feeding the mouth, making tools, playing the most complicated music, writing, and the creation of all art. Man's intelligence would be of little avail without these wonderful organs. Man's face has also reached the limit of position, as compared with the lower animals, in being shifted from a position in line with the dorsal side of the body to a position in line with the ventral side. This shifting, along with the expansion of the brain, has placed the brain instead of the mouth at the end of man's body. Man's voice apparatus and mouth are also extraordinary developments and can be employed in a multitude of ways in addition to their use in speaking and singing. The specially gifted and developed human singer has no compeer among all the vocal animals of the earth.

It is clearly evident to the contemplative scientist, as stated by Henry Fairfield Osborn, that the human brain is the most profoundly marvelous and mysterious object in the whole material universe. It is in some mysterious manner the instrument of the mind, subject to the will of the self-conscious, reasoning, creative, and inventive personality. This small body is more complicated in units of structure or cells and infinitely more complicated in interaction of these units than our entire, heavenly galaxy of suns. It has been estimated, on a conservative basis, that there are over twelve billions (12,000,000,000) of cells in the human brain alone, and it is evident that the

self-conscious personality, my ego, controls this amazing mechanism and other billions of cells of the body to a definite purpose while this sentence is being written. There are about two billions of human individuals on the earth at the present time. Thus, one brain contains at least six times as many structural, biological units as the entire population of the world. One could make a present of six of his brain cells to every man, woman, and child now on the earth. Moreover, each cell has a nucleus with forty-eight chromosomes which can be counted under the microscope and which contain the Mendelian hereditary potentialities or genes. Thus, there are in the brain more than half a trillion chromosomes which, because they form the most important part of the living substance, must certainly be involved in this control of the intelligence and will, not only in producing the inconceivably complex co-ordination involved in the mechanical and chemical activities but also in the production of the conscious thoughts themselves.

Comparing the human brain still further with the amazing numbers which astronomers give of the suns in the starry heavens, the brain does not take any subordinate position in so far as mere numbers are concerned. About one billion stars are within reach of the 100-inch telescope on Mt. Wilson, California. Thus the brain contains more than twelve times as many biological, cell units as the number of stars visible in this great telescope. According to some estimates there are forty billion stars (suns) in our own galactic system. Thus since a man has more than 576 billions of chromosomes in his brain, he carries about in his cranium as many of these important biological units as there are suns in fourteen galactic universes of the size of our own. Carrying this mathematical diversion a little farther, it may be stated that it has been estimated that the normal human body contains twenty-six trillion cells. Thus, with forty-eight chromosomes in each cell, the total number of chromosomes in the human body reaches the marvelous number of more than one quadrillion (1,248,000,000,000,000). In round numbers we can say that our bodies contain as many cells, or structural, biological units as the calculated suns contained in 650 galactic systems the size of our own milky way, and as many chromosomes as the suns of 31,200 galaxies. Thus we can justly exclaim with the Psalmist of long ago: "I am fearfully and wonderfully made."

The mind through the action of the brain recreates the universe from a few simple irritations of nerve endings on the surface of the body, a few pressures on the skin, a few vibrations in the ears, a few rays of light impinging on the retina of the eyes, a few chemical stimuli on the mucus membranes of the mouth and nostrils—these simple irritations impinging on the sensory nerve endings set up nervous impulses which are conveyed along the nerve strands not as touch, sight, sound, taste, or smell but simply as electrical or mechanical processes to be transformed in the hidden chambers of the brain cells into sensations and mental pictures from which each person, through the action of the reason, constructs an intelligent system, a world, a cosmos, a universe. Thus we attain to a knowledge of the outside world as a reality and also to the apprehension of our own selves as distinct from all that surrounds us. This is the determinate limit of the evolutionary process. Then there is another great mechanical marvel, entirely incomprehensible when compared with ordinary mechanisms, namely that sometimes persons have lost considerable portions of both frontal lobes of the brain, with the destruction of myriads of brain cells, without impairment of their intelligence after the wounds were healed, so long as at least one lobe has not been seriously damaged. However, something that poisons or injures a large part of the cellular structure, as for example the presence of narcotics or alcohol, causes a decided confusion in the action of the mechanism. Nor must we forget the fact that all these human brains and personalities are unique. Nature makes an elaborate mould in which to mould one human individual and then throws it away. Each individual becomes a decidedly unique thing in the universe never to be exactly repeated, not even in identical twins. It is evident that a humanity of closely similar individuals would, from a philosophical point of view, be a profound miscarriage of the creative, evolutionary process.

The development of individuality becomes quite pronounced in the higher animals, but is, of course, enormously less than in human beings. Thus our principle of the evolution of unique and extraordinary characteristics at the ends of the progressive, phylogenetic series is seen to be one of the most important and fundamental aspects of the evolutionary process. The result has been an organism with the capability of promoting extreme good or extreme evil in the realm of nature and man. This problem must be a primary concern of scientific study as well as

of moral and spiritual discipline, if the improper use of intelligence and science is not to destroy the very foundations of civilization, through the progressive invention of mechanisms which can be employed for evil and destructive purposes by those who may obtain political and social control. Finally, it must be especially emphasized that the human self-consciousness is a unique phenomenon in the biological realm. A higher animal may think but there is absolutely no evidence that it knows that it is thinking or that it knows of its own existence. If it did it could easily tell us so by word or sign. But not one animal idea has ever been recorded.

The extraordinary developments in man and the higher animals are not to be explained on special teleological grounds. Teleological hypotheses receive no confirmation in fact from a scientific study of the taxonomic systems in relation to their environment. This fact is evident to any one who has the merest acquaintance with the taxonomic system. Mice and men all live in essentially the same environment, and mice usually insist on living in man's immediate domicile; and for mere physical survival men need no more brains than do mice or elephants.

The extraordinary developments, whether mental or physical, are a part of the general evolutionary process and represent peculiar products appearing in advanced members of phylogenetic series, especially in organisms with very complex hereditary systems. They are the results of an intrinsic, mutative process that has been operative in the protoplasm during the geological ages and which we designate, scientifically, by the general term, creative evolution.

---

### Stellar Dynamics

Behind this imposing title is an imposing book written by a man who is master of his subject. The material is for the advanced student and is highly mathematical in its treatment of the several problems which are concerned with the movement of stars in space. The book is a member of the most advanced series of mathematical treatises sponsored by the Cambridge University Press. It is not recommended to any but those who have thorough training in the solution of differential equations and theory of functions. The problems in stellar dynamics are treated in cartesian, cylindrical and polar coordinates. Vector analysis is not used, a fact which is surprising because at least one of the problems discussed could have been treated better by vectorial methods than by those which were used.

The reviewer has worked through that portion of the book which deals with the problem of rotation of the galaxy. The mathematical treatment was found to be straight-forward, definite and clear. Less detailed examination of the remainder of the book indicates that it should be highly recommended to students of dynamical problems in astronomy.—*C. E. Hesthal.*

*Stellar Dynamics*, by W. M. Smart. viii+434 pp. Cambridge at the University Press; in New York, the Macmillan Co., 1938. \$8.50.

# A CRITICAL ANALYSIS OF THE MOVEMENTS OF THE SHOULDER-JOINT

LINDEN F. EDWARDS

Department of Anatomy, The Ohio State University  
Columbus, Ohio

Although much has been written concerning the morphology of the shoulder-joint of the various Tetrapods, as well as the nature of the movements permitted, the writer is of the opinion that certain terms relative to the movements of this joint in man should be clarified. It is generally agreed that, although considerable variation exists in the range of movements, in Mammals the humerus may undergo flexion, extension, abduction, adduction, medial (internal) and lateral (external) rotation round its longitudinal axis and a combination of these movements called circumduction. The term abduction with reference to the shoulder-joint is invariably used to indicate elevation of the humerus laterad and adduction to signify depression of the humerus from the latter position toward the side (mediad).

However, as regards the use of the terms flexion and extension as applied to the shoulder-joint considerable discrepancy exists between the various aspects of anatomy. It is with the interpretation and employment of these terms that the present paper is concerned. The term flexion in general is usually defined, or conceived of at least, as being that movement at a joint whereby the angle between corresponding surfaces of the apposed bones is decreased whereas extension is considered to be that movement in which this angle is increased. The connotation of these terms is evident in the case of angular joints such as the elbow and knee. However, in the case of multiaxial joints, and more especially the shoulder-joint, these movements are rather difficult to classify on the basis of this criterion.

In textbooks of Comparative and Veterinary Gross Anatomy flexion of the quadruped shoulder-joint is interpreted as swinging backward (caudad) of the humerus and extension as swinging forward (craniad) of the humerus. The criterion employed for this classification in these texts is the displacement of the dorsal surface of the humerus with respect to the caudal border



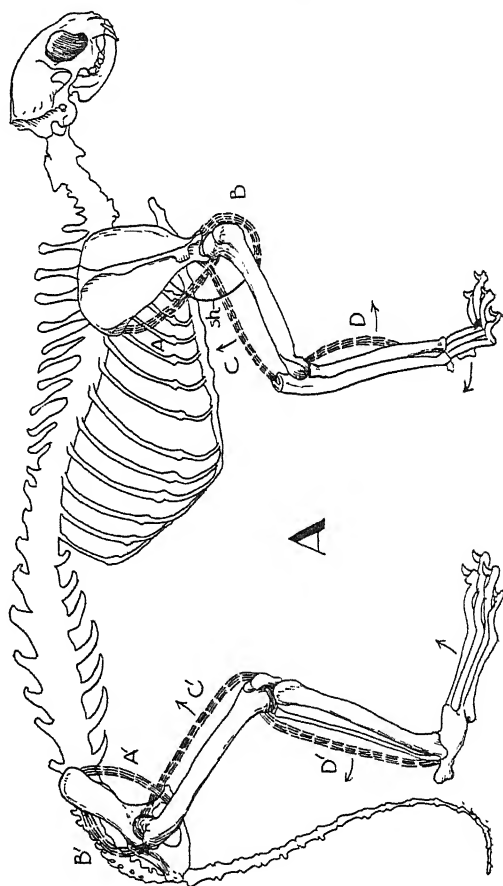
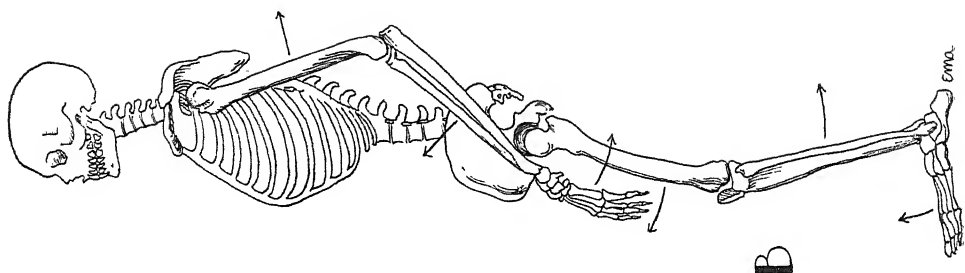
FIGURE 1—A

Skeleton of cat showing the normal position assumed by the various segments of the limbs and the groups of muscles illustrating "mirror image" relation.

A, *Latissimus dorsi*—teres major group of muscles; A', Iliopsoas group; B, M. Deltoides; B', M. Gluteus maximus; C, M. Triceps brachii; C', M. Rectus femoris; D, Anterior antibrachial mass; D', posterior leg muscles and Sh, scapulohumeral angle.

FIGURE 1—B

Human skeleton. The arrows indicate that corresponding segments are "flexed" (?) in opposite directions.



of the scapula (figure 1A) so that flexion (swinging backward) of the humerus results in decreasing the scapulo-humeral angle, whereas extension (swinging forward) results in increasing this angle.

Diametrically opposed to this conception of flexion and extension of the shoulder-joint is the view adopted in the modern editions of most standard textbooks of Human (Gross) Anatomy. For example, in Quain's Anatomy, eleventh edition ('23), under the description of the action of the muscles which operate on the shoulder-joint (p. 115), appears this statement: "The movements of the arm, though difficult to classify, are best described by starting with the humerus in the hanging position. From this position it may be carried directly forwards to the horizontal plane—this movement is usually termed flexion—and then be elevated to the vertical position; oppositely it may be depressed to the hanging position, and then be carried backwards or extended."

Moreover, there is general agreement among human anatomists that the muscles involved in the production of flexion (swinging forward) of the humerus at the shoulder-joint are the coracobrachialis, the short head of the biceps brachii, the pectoralis major and the anterior fibers of the deltoid, whereas those involved in the production of extension (swinging backward) of the humerus are the latissimus dorsi, the teres major, the long head of the triceps brachii and the posterior fibers of the deltoid. In texts of Comparative and Veterinary Gross Anatomy, on the other hand, the flexor and extensor muscles of the quadruped shoulder-joint are classified as just the reverse of those in Human Anatomy.

In older editions of Human Anatomy texts the terms flexion and extension were not employed either in connection with the description of the shoulder-joint or with the muscles which act upon this joint. Apparently the issue was avoided by stating merely that the humerus "swings forward" and "backward" at the shoulder-joint and in the case of the muscles that they "draw the humerus forward" or "backward" as the case may be. However, in the older editions of Gray's Anatomy ('87) under the description of the triceps muscle it was stated that "when the arm is extended (sic) the long head of the triceps may assist the teres major and latissimus dorsi in drawing the humerus backward." It is evident, therefore, that in spite of the fact that these terms were not employed

in connection with the description of the movements of the shoulder-joint the implied meaning of the term "extension" of this joint was similar to that still in use in Comparative and Veterinary gross Anatomy. On the other hand, these terms were evidently employed in the same manner as used today before they were generally adopted in Human Anatomy textbooks as is evident by this statement of Wyman (1867): "If we admit the idea of symmetry in structure between arms and legs, and would compare the movements of the two in men and animals, we must change in some respects the terms flexion and extension, from those ordinarily used in the description of the human body. We will suppose the human skeleton suspended with the vertebral column horizontal, the limbs slightly flexed, the toes and fingers pointing downwards, the palms facing forwards and the soles backwards. Flexion of the humerus would be backwards, of the femur forwards." A review of the literature previous to as well as subsequent to the date of Wyman's paper has failed to cast any light on the question as to the explanation for the adoption of these terms as now used with reference to the human shoulder-joint.

Inasmuch as such a discrepancy exists between the various phases of anatomy with respect to the use and interpretation of the terms flexion and extension of the shoulder-joint, with the resulting confusion experienced by the student and much necessary explanation required on the part of the teacher in Human Anatomy, it occurred to the writer that some effort should be made to analyze the problem with the view to clarifying it or at least to arousing sufficient interest among human anatomists that some agreement eventually be arrived at relative to the terminology employed in connection with the human shoulder-joint. Aside from the academic aspect of the problem it is hoped that its solution would serve to enable the student to make a better adjustment between his courses in Comparative and Human Anatomy.

The objective aimed at in this paper is not to offer an explanation for, or to refute, the present concept of these terms prevailing in Human Anatomy but rather to raise certain questions bearing upon this concept. If, for example, flexion of the shoulder-joint in quadrupeds is regarded as swinging backward (caudad) of the humerus, whereas in biped man it is considered as swinging forward (craniad) can these divergent views be explained on the basis of man's assumption of an erect

posture, that is on the fact that man's pectoral limb was converted from an organ of progression or locomotion into one of prehension? If this explanation is tenable is swinging forward of the humerus of the child who is learning to "crawl on all fours" to be regarded as flexion or extension? Conversely which of these terms should be applied to swinging forward (craniad) of the humerus of those quadruped animals which are able temporarily to assume a biped mode of locomotion, such, for example, as the bear?

The characteristic attitude of the fetus is well known and the advantages of such a posture for conservation of space and for the presentation or passage of the fetus through the birth-canal are obvious. As regards this normal attitude, habitus or posture of the fetus is it true, as De Lee ('33) states and as is generally described, that it is one of flexion of all the joints? In this position the humerus of the child as well as that of most quadrupeds is displaced forward or craniad. Is the shoulder-joint of the human fetus to be regarded as in flexion, whereas, in the quadruped fetus it is to be considered as in extension?

Is it likely that the comparative anatomists are incorrect in their interpretation and that the conception of the human anatomists is the correct one? Or is it possible that the view adopted by the comparative anatomists is correct as regards quadrupeds but that this conception does not hold for biped man? If the comparative view-point is incorrect or, on the other hand, if it holds true only for quadrupeds then of what value is anatomical interpretation of the comparative anatomists to human anatomy in this instance? Or is it perhaps an unfortunate use of terminology employed by both Comparative and Gross Anatomists, that is, a matter of using physiological terms with a disregard to the true morphological relationship?

According to the comparative anatomists the fore and hind limbs of quadrupeds, or the superior and inferior extremities of man, are constructed on a common plan, each limb being divisible into three segments.

Wilder (1866) made the observation that "corresponding segments point and are flexed or extended in absolutely opposite though relatively similar directions." Thus, in the quadruped, as the cat for example, (fig. 1 A), the brachium extends ventrad and caudad, the antibrachium ventrad and slightly craniad and the manus is directed ventrad in alignment with the antibrachium with the palmar aspect facing caudad. In the

hind limb the thigh extends ventrad and craniad, the leg ventrad and caudad and the pes ventrad and craniad. In each limb, therefore, the segments are directed ventrad and craniad or ventrad and caudad so that corresponding segments in the two limbs extend in opposite directions. Moreover, flexion of the distal segments of the limbs involves, in the case of the forelimbs, bringing the palm of the manus toward the caudal or posterior aspect of the antibrachium (fig. 1 A) at the radiocarpal or wrist-joint, and in case of the hindlimb the anterior or cranial aspect of the pes toward the front of the leg at the ankle-joint; flexion of the antibrachium involves approximation of its anterior surface toward the anterior surface of the brachium at the elbow-joint and in the hindlimb flexion of the leg comprises approximation of its posterior surface toward the posterior surface of the thigh at the knee-joint. In the case of the proximal segment of the hind limb it is generally agreed that flexion of the thigh in both man and quadrupeds involves swinging its anterior aspect craniad at the hip-joint. If Wilder's statement be followed to its logical conclusion does it not follow, therefore, that flexion of the brachium would involve swinging its posterior or dorsal aspect caudad at the shoulder-joint, or in other words, decreasing the scapulo-humeral angle?

Does the position of the scapula and humerus of quadrupeds in comparison with those of man form a basis for an explanation of these divergent views? When we analyze the position of the scapula of quadrupeds, as for example the Carnivora, (fig. 1 A), we observe that it lies almost parallel with the median plane of the body, the glenoid fossa facing ventrad, the subscapular fossa mediad, the supraspinous and infraspinous fossae laterad and with its borders or margins directed craniad, caudad and dorsad, respectively. Correlated with the assumption of the upright posture of man was a change in the position of his scapula (fig. 1 B), which is situated on the dorso-lateral aspect of the thoracic wall. This shift backward (dorsad) of the scapula may be explained as resulting from a lateral expansion of the thorax, its transverse diameter having become relatively greater and its antero-posterior diameter relatively less. In man, therefore, the scapula is situated more nearly at right angles to the median plane of the body so that the glenoid fossa faces ventro-laterad, the subscapular fossa ventro-mediad and the supraspinous and infraspinous fossae dorso-laterad.

As regards the borders or margins the (original dorsal) medial or vertebral border lies on a plane almost at right angles to the spinous processes of the vertebrae rather than parallel with them as in quadrupeds; the (original anterior or cranial) superior border is still directed craniad and the (original caudal or posterior) axillary border still faces somewhat caudad but, as a result of the elongation inferiorly of the scapula and of its dorsal position, the latter border is directed ventro-laterad.

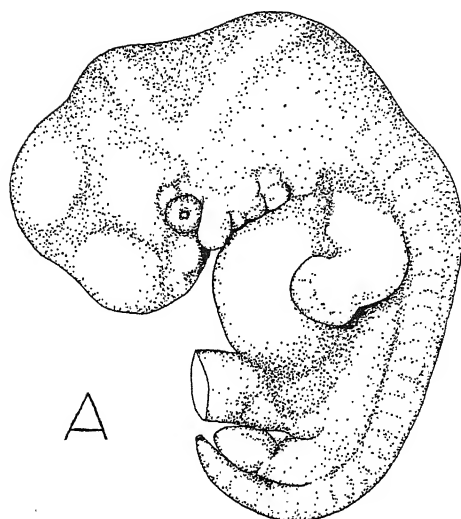
In quadrupeds the head of the humerus is situated on its dorsal aspect and, as a result of the position assumed by the humerus of a quadruped while standing or walking, it is directed dorso-caudad in apposition with the glenoid fossa which is directed ventro-craniad. As regards the position of the humerus in man it is well known that in the normal anatomic position of the human body it lies parallel with the longitudinal axis of the body, which in the human is vertical to the supporting surface as compared with quadrupeds in which it is parallel, so that the elbow-joint lies close to the side of the body. The dorsal and ventral (ventro-lateral and ventro-medial) surfaces of the humerus therefore face directly backward (dorsad) and forward (ventrad), respectively. Accompanying the change in the position of the human scapula and the direction its glenoid fossa faces has been a corresponding change in the position of the head of the humerus which is directed dorso-mediad or almost entirely mediad. This shift in position of its head has been explained by numerous writers as the result of torsion which the bone has undergone. In spite of these evolutionary changes of the human scapula and humerus, including the fact that the transverse axis of the human shoulder-joint for swinging forward and backward has shifted somewhat due to the change in position of the head of the humerus and glenoid fossa of the scapula, does not the scapulo-humeral angle remain approximately the same as in quadrupeds (fig. 1, A and B)?

According to the theory of "mirror relation" as proposed by Parsons (1908) and Geddes (1912) there is a looking-glass symmetry or mirror image repetition of the girdles and segments of the limbs, that is the hind limb of either side is a mirror image of the fore limb of its own side just as it is a mirror image of the hind limb of the opposite side. Thus the caudal border of the scapula corresponds with the cranial border of the ilium, and the lesser trochanter of the femur with the lesser tuberosity of the humerus so that the *teres major* and *subscapularis* mus-

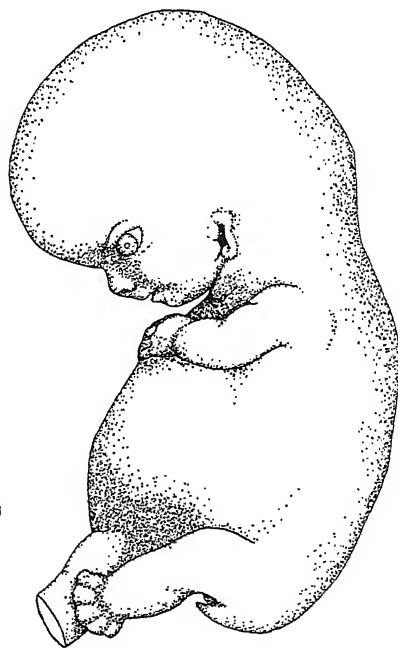
cles (fig. 1-A) correspond with the iliopsoas muscle ( $A^1$ ); the clavicle corresponds with the ischium, the gluteal tuberosity of the femur with the deltoid tuberosity of the humerus and the deltoid muscle (B) with the gluteus maximus ( $B^1$ ); the infraglenoid tuberosity of the scapula corresponds with the anterior inferior iliac spine, the olecranon process of the ulna with the patella and the triceps muscle (C) with the rectus femoris ( $C^1$ ); the coracoid process of the scapula corresponds with the pubis and the coracobrachialis muscle corresponds with the adductor magnus, et cetera.

On the basis of this theory, if followed to its logical conclusion, does it not appear reasonable that if the rectus femoris muscle extends the leg at the knee-joint and flexes the thigh at the hip-joint that the corresponding muscle, namely the triceps, which extends the antibrachium at the elbow-joint, would therefore flex, that is draw backward or caudad, the brachium at the shoulder-joint? Similarly if the iliopsoas muscle flexes the hip-joint would not the subscapularis—teres major group, therefore, flex the shoulder-joint?

In conclusion, the question naturally arises as to which of these opposing views conforms to the true morphological or embryological history of the limbs. A brief review of the stages through which the vertebrate limbs pass in their phylogenetic and ontogenetic development brings out the following: when the limbs first make their appearance their longitudinal axes lie parallel with the longitudinal axis of the body and are directed caudad, the ulna and fifth finger looking dorsad and the palmar and plantar surfaces of the manus and pes facing mediad (fig. 2A). In many Mammalia a secondary modification occurs in which the limbs are extended at right angles to the body and lie parallel to each other. In this position each limb presents a dorsal and ventral surface and an anterior or preaxial and a posterior or postaxial border. The dorsal surface of the forelimb, or superior extremity of man, includes the back of the manus and the so-called extensor surface of the antibrachium and brachium while the dorsal surface of the hindlimb, or inferior extremity, includes the dorsum of the pes, the front of the leg and the extensor surface of the thigh. The preaxial border of the forelimb comprises the pollex, radius, lateral (external) condyle and greater tuberosity whereas that of the hindlimb comprises the hallux, tibia, medial (internal) condyle of the femur and the lesser trochanter.



A



B

Fig. 2. Human embryos showing position of limbs at A, 31-34 days (11 mm.) and B, 42-45 days (16 mm.), after His.



In a later stage of development the distal extremities of the limbs are directed ventrad, with their longitudinal axes still at right angles to that of the body, the palmar surface of the manus and the plantar surface of the pes face mediad, while the elbow points caudad and the knee craniad (fig. 2B). The next stage is characterized by rotation of the limbs around their longitudinal axes through an angle of 90 degrees, the direction of rotation of the fore and hindlimbs being reversed. Thus the forelimb is rotated laterad with the result that the preaxial border is directed laterad, and the ventral surface faces craniad; the hindlimb is rotated mediad so that its preaxial border is directed mediad, its (original) ventral surface faces caudad and the hallux lies on the inner or medial border of the pes. Finally, in nearly all terrestrial mammals the antibrachium is rotated mediad or pronated so that the manus swings round from the back to the front of the limb with the distal end of the radius overlapping the ulna in which position it remains fixed in most quadrupeds. In the so-called normal anatomic position of man, however, the body is erect and the fore limb or superior extremity is pendant with the palmar aspect of the manus facing ventrad and the preaxial border, that is the pollex, the radius and the lateral border of the humerus, is directed laterad.

### CONCLUSIONS

It is generally concluded, therefore, that the hallux is homologous with the pollex, the palmar surface of the manus with the plantar surface of the pes, the tibia with the radius, the knee with the elbow, the ventral or anterior (original dorsal) surface of the leg and thigh with the (original) dorsal or posterior aspect of the antibrachium and brachium and so on. Furthermore, in the light of these conclusions, it is evident that the dorsal musculature of the brachium, that is the triceps complex which extends the antibrachium at the elbow, corresponds with the ventral (original dorsal) musculature of the thigh which extends the leg at the knee; the dorsal antibrachial musculature, which extends the manus and fingers, corresponds with the ventral (original dorsal) musculature of the leg which, however, is said to flex (dorsi-flex) the pes and to extend the toes. As regards the latter discrepancy as well as the action of the dorsal and ventral musculature of the thigh and brachium at the hip- and shoulder-joints, respectively, in the light of

their true morphological relationships what conclusions could be reached?

McMurrich ('23), in discussing this problem, remarked (p. 106) that "It may be pointed out that the prevalent use of the physiological terms flexor and extensor to describe the surfaces of the limbs has a tendency to obscure their true morphological relationships. Thus, if, as is usual, the dorsal surface of the arm be termed its extensor surface, then the same term should be applied to the entire ventral surface of the leg, and all movements of the lower limb ventrally should be spoken of as movements of extension and any movement dorsally as movements of flexion. And yet a ventral movement of the thigh is generally spoken of as a flexion of the hip-joint, while a straightening out of the foot upon the leg—that is to say, a movement of it dorsally—is termed its extension."

If the (original) dorsal musculature of the limbs is to be considered an extensor group and the (original) ventral musculature a flexor group, as is generally held by the majority of morphologists, does it not follow, therefore, in the light of this interpretation, that swinging forward (that is ventrad in the human or craniad in quadrupeds) of the humerus should rightly be termed flexion whereas swinging forward of the femur should in reality be called extension; that bringing the palm toward the ventral aspect of the antibrachium is correctly named flexion, whereas displacement of the sole toward the posterior (original ventral) aspect of the leg, as in "standing on tip-toes" should really be termed flexion rather than extension?

Indeed the whole subject of the action of the musculature of the limbs is badly in need of revision and, insasmuch as the present paper is largely analytical and more or less subjective, the writer recommends that the question be thoroughly reconsidered with the view to clarifying the existing confusion.

#### REFERENCES

- De Lee, J. B. (1933). *Principles and Practice of Obstetrics*. (6th ed.), Philadelphia and London.
- Geddes, A. C. (1912). *J. Anat. Physiol.*, Vol. XLVI, pp. 350-383.
- Gray (1887). *Anatomy* (2nd Am. ed.), Philadelphia.
- McMurrich, J. P. (1923). *The Development of the Human Body*. Philadelphia.
- Parsons, F. G. (1908). *J. Anat. Physiol.*, Vol. XLII, pp. 388-396.
- Quain (1923). *Anatomy*, Vol. IV, pt. 2, p. 115. London.
- Wilder, B. G. (1866). *Proc. Bost. Soc. Nat. Hist.*, Vol. I, p. 3-6.
- Wyman, J. (1867). *Proc. Bost. Soc. Nat. Hist.*, Vol. II, pp. 246-278.

## AN ANOMALOUS ARTERY IN THE KINGFISHER (CERYLE ALCYON)

FRED H. GLENNY

Department of Biology, University of Akron

During a recent dissection of two mature specimens of the Belted Kingfisher (*Ceryle alcyon*), an anomalous artery was observed. The specimens which were used were obtained at the State Fish Hatchery No. 10, near Akron, Ohio, in August, 1937.

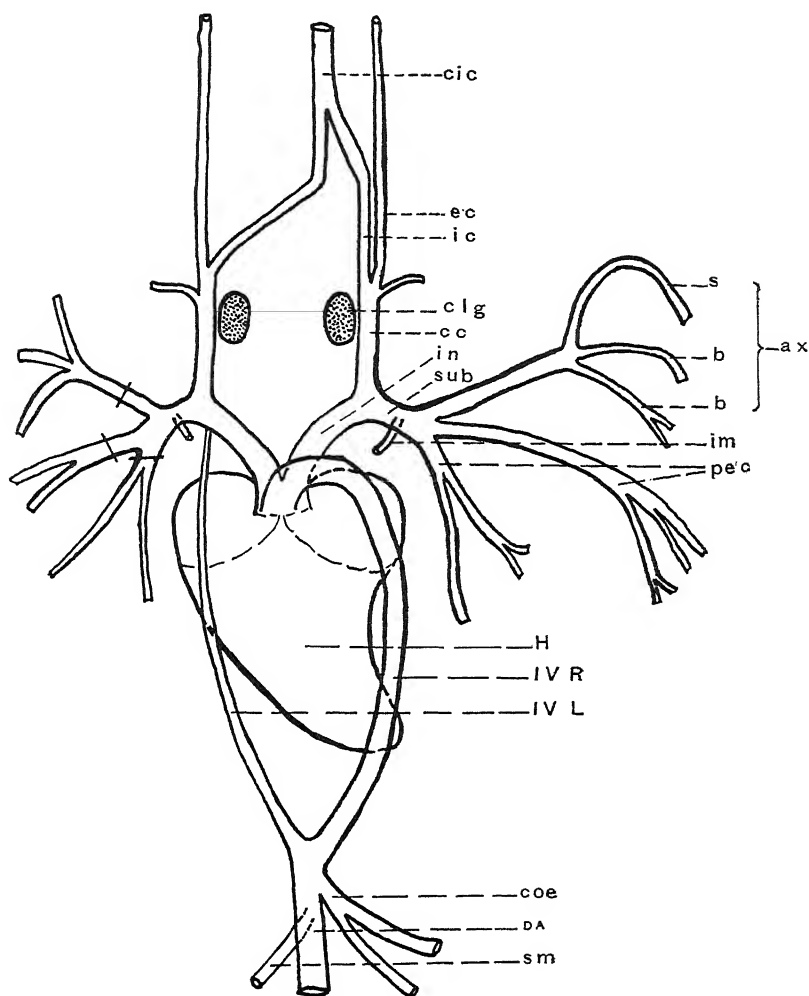
At the posterior end, this vessel arises from the dorsal aorta in the same fashion as the normal 4th right aortic arch (dorsal aorta). It is on the left side of the body just anterior to the coeliac and mesenteric arteries. This left vessel proceeds anteriorly along the sub-vertebral musculature of the thoracic cavity toward the neck where it ends in the muscle fibers and surrounding fascia at the base of the neck just anterior to the left lung. It does not form an anterior ligamentous connection with the right 4th aortic arch or any other major artery at the base of the heart.

Dr. Berry Campbell, of the University of Oklahoma, remarked that there are minute twigs given off all along the course of this vessel. Further he says, "These twigs are not true intercostals, however, and probably in this species . . . the intercostal arteries are branches of a caudal continuation of the vertebral arteries."

There are three primary branches of the aorta giving rise to the right aortic arch and, almost immediately anterior, to the innominate arteries which then give rise to the subclavian arteries. This differs somewhat from Beddard's expected condition (1) which indicated that the dorsal aorta arises from the right innominate artery.

After consideration of the data given above, the burden of proof seems to indicate that this anomalous artery is a persistent embryonic left 4th aortic arch. It is, therefore, one of the few cases of this kind thus far reported in mature specimens. Beddard (1) refers to injection of a similar vessel in *Spizaetus* and *Aceros*, but no further reference has been located.

Due to the meager amount of literature on this subject, the matter was referred to several anatomists at other institutions. Dr. E. G. Butler, of Princeton University; Dr. D. P. Quiring,



Semi-diagrammatic Sketch of the Main Arteries of the Kingfisher (*Ceryle alcyon*) in the Region of the Heart—Dorsal View

#### EXPLANATION OF ABBREVIATIONS

- |                                      |                               |
|--------------------------------------|-------------------------------|
| cic—common internal carotid artery   | ax—axillary artery            |
| ec—external carotid artery           | im—internal mammary artery    |
| ic—internal carotid artery           | pec—pectoral arteries         |
| clg—thyroid gland                    | H—Heart                       |
| cc—common carotid artery             | IV R—Fourth right aortic arch |
| in—innominate artery                 | IV L—Fourth left aortic arch  |
| sub—subclavian artery                | coe—coeliac artery            |
| s—shoulder branch of axillary artery | DA—dorsal aorta               |
| b—brachial arteries                  | sm—superior mesenteric artery |

and the late Professor T. Wingate Todd, of Western Reserve University; and Dr. Berry Campbell, of the University of Oklahoma concur in the interpretation that this vessel is a persistent 4th left aortic arch. Dr. W. C. Kraatz and Dr. E. P. Jones, of the University of Akron, made early observations on the two specimens and found that it was located in the position of the embryonic left 4th aortic arch.

#### REFERENCE

- (1) **Beddard, Frank E.** 1898. *The Structure and Classification of Birds*. London, Longmans, Green and Co.

---

#### A Century of Progress

The reader is likely to be a little misled by this book as to the full meaning of the word "Astronomy." Although the volume is entitled "100 Years of Astronomy," little mention has been made of the developments and importance of the work done in that portion of astronomy having to do with fundamental positions of stars and the particular class of problems associated with these positions. The book would have better been entitled "100 Years of Astrophysics." With this idea clearly in mind, the reader can settle back with many hours of enjoyment ahead of him because the book tells a long and fascinating story. Sympathy with the author is quickly established. One has the feeling that he is absorbed in his story; impatient even, to tell it. Although the author makes mistakes from time to time, these will cause the critical reader more amusement than annoyance because all are overshadowed by the author's earnestness in telling his tale forcibly and well. The book is non-technical and can be understood easily by the reader who has only the most elementary knowledge of astronomy. An excellent bibliography of seven pages closes the volume. This reviewer recommends the story to the general reader without reservation.—*C. E. Hesthal*.

**One Hundred Years of Astronomy**, by Reginald L. Waterfield. 526 pp. New York, the Macmillan Co., 1938. \$5.75.

---

#### Ion Mobility

This tract is one of a group which provides authoritative accounts of subjects of topical physical interest. With the subject matter treated here the author has been closely connected in research over a period of many years. In fact, most of the material presented consists of results of his laboratory investigations which are sufficiently extensive and complete that they, in themselves, form a connected treatise leading to the best present day knowledge about the motion of ions and ion aggregates in various gases over a large pressure range.

In seven of the eight chapters of about twelve pages each the experimental aspects are interestingly presented—ion sources, methods of measuring ion velocities, detection of ion clusters, diffusion effects and temperature effects. The other chapter is devoted to theory. Thirty-five figures, three tables and a clear handling of the selected essential factual material make this small book a most desirable one for obtaining quickly the salient features of a subject matter that seems, from the research point of view, fairly well completed. The book should prove especially useful to senior college and graduate students in mathematics, physics and chemistry and be a valuable addition to a physical science library.—*M. L. Pool*.

**The Mobility of Positive Ions in Gases**, by A. M. Tyndall. Cambridge at the University Press, in New York, the Macmillan Co., 1938. \$1.75.

# THE ORIGIN AND DEVELOPMENT OF THE INTERNAL MUSCULATURE OF THE FROG LUNG (*RANA PAPIENS*)

F. A. WATERMAN

Department of Zoology, The Ohio State University,  
Columbus, Ohio

## INTRODUCTION

The general literature regarding the histological structure of the frog lung is quite ambiguous on certain points. There is much disagreement concerning the distribution of the arteries and the veins and their relationships to one another. Whether or not cilia are present in the frog lung is also controversial. Neither is there any agreement about the component parts of the alveolar septa; nor is any information concerning their development available. Smooth muscle is known to be present in the lung, but there is no accurate information concerning its distribution and morphology. Therefore, the writer undertook a histological and embryological investigation of these points.

## LITERATURE

The veins and the arteries are distributed as companions to one another, according to the sketches of Renaut (1897), and copied by Oppel (1905), Winterstein (1921), and Holmes (1927). This is in complete disagreement with Küttner (1874), Wiedersheim (1882), and Gaupp (1904), who found the pulmonary artery on the periphery of the lung coursing its way from the root to the apex, giving off numerous lateral branches along the way and a main pulmonary vein on the extreme interior, collecting the blood from the intervening capillary network and returning it toward the root of the lung.

Renaut's diagram of a section through the lung is misleading with respect to the distribution of cilia. He shows cilia present only in the tracheal tube at the root of the lung. On the other hand, Küttner, mentioned above, as well as Hoffman (1878), Haslam (1889), and Königstein (1903), find cilia not only in the tracheal tubes, but also on the margins of the numerous longitudinal and transverse septa on the interior of the lungs.

In regard to the internal septal partitions of the lung, Bourne (1909) has stated that they are found less developed in

the lower portion of the lung wall and are completely absent in the apex. This is contrary to the diagrams of Miller (1893), Renaut, and Oppel, who find them as completely formed in the apex and lower portion as in the region near the root.

Of special interest were the accounts of various writers concerning the smooth musculature of the frog lung. Those will be discussed in chronological order.

Arnold (1863) describes the distribution of the elastic and smooth muscle fibers in the alveolar and septal walls of the frog and of the human lung. He speaks of the smooth muscle fibers as being the essential structural constituent of the frog lung.

Küttner (1874) mentions that the smooth muscle forms in the lung of the frog, "a scaffolding for the support of the arteries and nerves, and for the veins a protective cap located in the crown or inner margin of the numerous septa." He ascribes to this musculature the function of a tension regulator, presumably in reference to the intrapulmonic pressure.

Weidersheim and Haslam state that the lung musculature is arranged in large bands which form a network on the interior from which pass finer processes of muscle tissue in the septal walls toward the periphery where they join a thin and incomplete muscular layer in the external wall of the lung.

Thomson (1899) briefly describes the frog lung as a transparent oval sac with muscle fibers in its walls.

Königstein states that a histological section through the amphibian lung convinces one that the greater part of the compact lung substance consists of smooth muscular tissue. He assigns to this musculature the function of diminishing the size of the lung cavity, so that when the glottis is closed, the air in this cavity will be forced out into the peripherally arranged alveoli.

Gaupp (1904) states that the big veins of the lungs course only on the interior in the crowns (Kuppen) of the septa underneath muscle ridges (Randmuskelbalken).

Oppel (1905) has shown by diagram the distribution of smooth musculature in reference to a lung section and to an individual septal partition. In these his emphasis is entirely upon the distribution of the muscle bundles with complete disregard of the veins which are associated with them, in spite of the fact that he includes blood cells in his sketches. Regarding the blood vessels of the lungs, he relies upon the statements of other authors.

Brown (1909) registered graphically small pressure changes in the lung sac, after inhalation, with the glottis closed and attributed them to the contraction and relaxation of the smooth musculature of the lung.

Carlson and Luckhardt (1920) describe the amphibian lung as a paired muscular sac in which the smooth musculature covers the entire wall and extends into the smallest septa of the interior. The arrangement of this musculature is such that its contraction will reduce the size of the lung cavity and raise the intrapulmonic pressure if the glottis is closed. In their studies they report the discovery of a "persistent peripheral motor automatism" which is normally repressed or controlled by inhibitory impulses from the central nervous system. Between breathing movements, (inhalation and exhalation) when the pause is of sufficient duration, they find an initial rise in the intrapulmonic pressure as did Brown, and, like the latter, conclude that it is due to the contraction of the lung musculature rather than to any other possible external or internal factor.

## HISTOLOGICAL STUDIES

### 1. METHODS

Histological preparations were made from fifteen frog lungs (*Rana pipiens*). Each was obtained immediately after pithing the brain and cord. The lungs were then severed at the roots and at once submerged in Bouin's fixative solution. Some of the lungs were prepared in the collapsed, others, in the inflated state. Each specimen was imbedded in rubberized paraffin for sectioning. Some of the series were stained in Delafield's hematoxylin and eosin; others, in orcein, a specific stain for elastic tissue; still others, in Castroviejo's triple stain, which is particularly good for showing muscular tissue distribution and for showing the presence of erythrocytes in the blood vessels. The blood vessels in most of these lungs were injected with India ink from the heart before being severed from the animal. This procedure very effectively aided the study of the distribution of the blood vessels (arteries, capillaries, and veins) throughout the entire lung structure.

### 2. DISCUSSION AND RESULTS

#### *Arteries*

According to Renaut, Oppel, and Winterstein, the arteries and the veins are distributed as companions to one another, whereas Küttner, Weidersheim, and Gaupp found a main pulmonary artery coursing its way from the root to the apex, giving off numerous lateral branches along the way. While a principal artery is present in some cases, this distribution is by no means invariable. Serial sections of four lung preparations show that the pulmonary artery divides into two branches.



One of these again subdivides, forming a total of three vessels of uniform size near the root of the lung.

### *Cilia*

Renaut found cilia to be present only in the tracheal tubes. In agreement with Küttner, Hoffman, Haslam, and Königstein, the writer finds cilia not only in the tracheal tubes but also on the margins of the numerous longitudinal and transverse septa throughout the interior of the lungs.

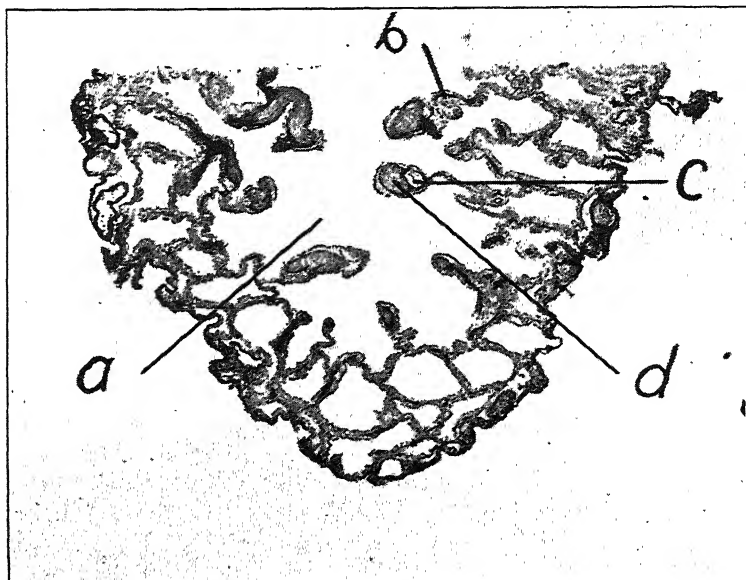


Fig. 1. Longitudinal section near the external wall, showing the peripherally arranged septa: (a) lung cavity, (b) internal septa, (c) small internal vein, (d) internal muscle bundle. 10  $\times$

### *Septa*

Bourne found the internal septal partitions less developed in the apex of the lung than in the root. This is contrary to the diagrams of Miller, Renaut, and Oppel and to my own observations. They are as completely formed in the apex and lower portion of the lung as in the region near the root. Fig. 1.

### *Musculature and Venous Return*

It is apparent from an examination of the literature that the great amount of disagreement concerns the distribution of the smooth muscle fibers and the venous system of the lungs. A great deal of this is, no doubt, due to the fact that the muscles and veins are structurally so closely associated that many writers investigating the one have failed to observe the other. Because of this close association, it will be necessary to discuss them together.

Most of the authors who have considered the muscular tissue declare it to be a structure independent of the adjacent veins; some of them even failed to observe the closely associated veins. A modification of Castroviejo's triple stain has been particularly helpful in making possible the interpretation of the histological structure of the internal septal marginal veins. Through this stain the muscle tissue appears in green; the white fibrous tissue, in blue; the erythrocytes, in yellow; and the nuclei, in red. With such a stain, that which all the preceding authors have mentioned as an independent muscular network on the interior of the amphibian lung appeared to the writer at first to be a constituent portion of these internal veins. These veins appear to differ from the typical vein in having the smooth muscle tissue, except rarely for a few scattered fibers, assembled asymmetrically in a single bundle on their free border. White fibrous connective tissue, which typically is found abundant in both the tunica intima and tunica externa of veins, is, in the case of these septal veins, merged into a single layer for two-thirds of their luminal circumference. For the remaining third, these layers separate and include the muscle bundle. Moreover, this bundle lies immediately adjacent to the tunica intima of these veins and also possesses numerous interwoven elastic tissue fibers, such as is found in the tunica media of veins. This gives it the appearance of being the tunica media, which has been concentrated in one side.

One cannot escape wondering why there is this peculiar assembling of the muscular tissue of these veins into this single bundle along their internal wall. If the view of the foregoing investigators as to the function of these muscle bundles is accepted, viz., that they act along with the other muscular tissue of the amphibian lung to reduce the size of the lung cavity and thereby raise the intrapulmonic pressure, it is easy to see that from a mechanical standpoint this would be an advantage. A single bundle of muscle fibers located on the free internal border of the septa would act with greater facility and with less impediment in reducing the size of the lung cavity than the same amount of muscle tissue scattered throughout the entire wall of these veins. In a sense this network of muscle bundles is really a complex internal lattice-like sphincter of inter-crossing, longitudinal and transverse, circularly-arranged strands, among which are interspersed elastic connective tissue fibers.

In fact, if the above hypothesis is correct, one may assign two functions to the muscular tissue of these veins, namely: that its contraction will bring about a rise in intrapulmonic pressure and, at the same time, be effective in increasing the blood flow through the pulmonary veins from the lungs. This action would increase the oxygen absorption (Gegenbaur, 1901) of the air in the lung cavity and force the freshly oxygenated blood back to the heart. Both of these functions have their counterpart among mammals in the action of the diaphragm and other inspiratory muscles. Thus, this vascular sphincter would not only perform its normal function of influencing circulation, but also assume a new function of assisting in breathing as well.

*Development of the Lung Musculature*

The study of the development of the Anuran lung has not extended in the past beyond the very young tadpole. Greil (1905) studied the gross development in *Rana temporaria*, *Bufo vulgaris*, and *Bombinator igneus*. His plates show wax reconstructions of the trachea and lung-bud anlagen, with the veins in blue and the arteries in red. The largest tadpole used was 8.4 millimeters.

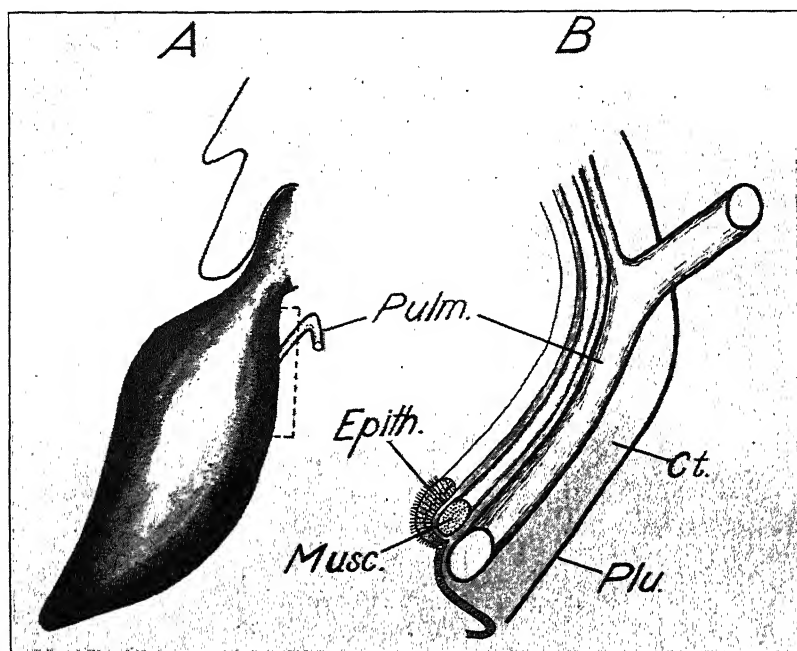


Fig. 2. A. Drawing of the left lung, showing exit of the pulmonary vein. B. Diagram of the dissected lung at portion indicated by dotted line in A. Pulm., pulmonary vein; Epith., epithelium; Musc., muscle; Plu., pleura; Ct., connective tissue.

Fedrow (1910) made a comparative study of the development of the lung veins in various vertebrates. The forms and sizes used were as follows:

<i>Rana temporaria</i> .....	4.4-11.7 mm.
<i>Triton taeniatus</i> .....	8.7-11.0 mm.
<i>Lacerta agilis</i> .....	32-38 somites
<i>Gallus domesticus</i> .....	3 days
<i>Cavia cobaya</i> .....	21 days

His object was to show in cross section the similarities of the location and structure of the developing lung sacs and their accompanying blood vessels. In all of his stages, the lung buds were only mere sacs of endoderm with no indication of developing internal septa and smooth muscles.

It seems illogical to think that the muscle network is tunica media because a vein of such construction is, to the writer's best knowledge, not found anywhere else in the animal kingdom. It would seem that the musculature must arise independently of the veins, and the latter become very closely associated with it so as to give a false appearance of being tunica media.

This is borne out by the following facts: The main pulmonary vein originates at the apex of the interior of the lung and courses anteriorly along its meso-lateral border for about three-fourths of the length of the lung. It then passes through the lung wall and proceeds onward to the left auricle. When this vein is on the inside of the lung, it has the same structure as the other veins associated with the musculature. If this muscle bundle is the tunica media of the vein, serial sections of the lung, reading from the posterior to the anterior, should show a transition from the asymmetrical to the symmetrical condition at the point where the vein takes its departure toward the heart. This, however, is not the case. When this point is reached, the muscle bundle continues in association with a tributary vein, while the main vein with a tunica adventitia passes on towards the left auricle. Fig. 2.

Since this problem could not be solved through adult anatomical study, the only alternative left was to study the frog lung from an embryological point of view.

#### *Materials and Methods*

The eggs of *Rana pipiens* were collected early in April, and at the time of collection, they were in the neural groove stage. Samples were taken each twenty-four hours for the first week. For the next two weeks, the samples were taken every forty-eight hours and from then on, twice a week until the animals emerged. When the tadpoles reached the stage where hind legs were beginning to develop, the lung buds were carefully dissected out, fixed, and sectioned. The slides were next stained by a dioxan modification of Castroviejo's (1932) method, Waterman (1937).

The critical stages in the development of the frog lung are as follows:

1. Late operculum.....	10.5 mm.
2. ....	13.5 mm.
3. ....	16.0 mm.
4. ....	30.0 mm.
5. ....	45.0 mm.
6. ....	60.0 mm.
7. Four legs and long tail.....	58.0 mm.
8. Four legs.....	56.0 mm.
9. Short tail.....	39.0 mm.
10. Very short tail.....	30.0 mm.
11. Tail practically resorbed.....	26.5 mm.
12. Small mature frog	
13. Mature frog, medium size	
14. Normal mature frog	

The sections showing the development of the lung and its musculature were then drawn.

### Discussion

The lung develops as an endodermal evagination of the floor of the pharynx. At the late operculum stage, this evagination consists of a single layer of somewhat cuboidal cells. The laryngo-tracheal groove is surrounded by loose mesodermal cells and a few strands of developing

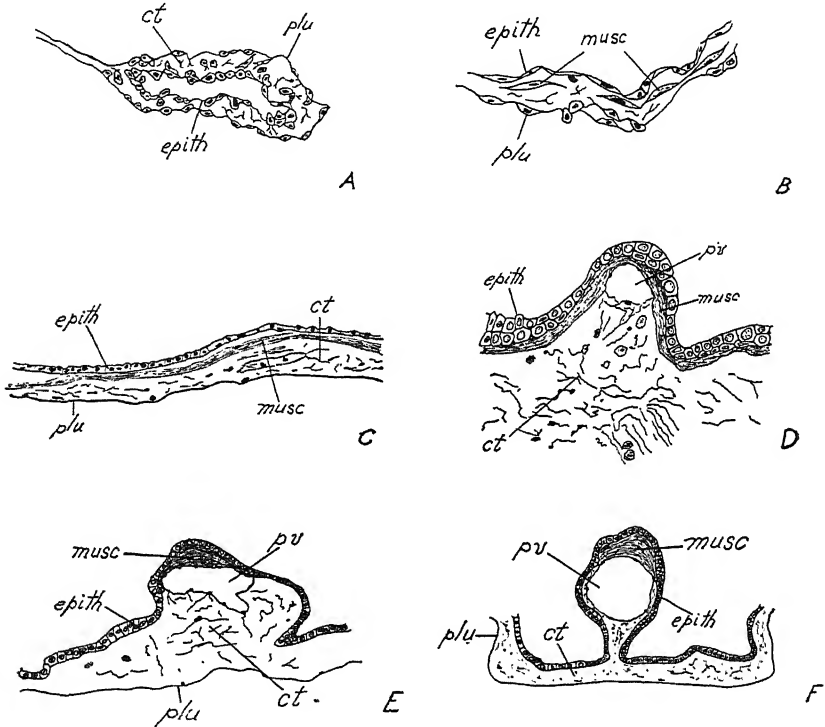


Fig. 3. Camera lucida drawings showing the formation of the alveolar septa and internal musculature of the anuran lung.

- A. Lung bud of a 10.5-mm. tadpole of the late operculum stage. epith., epithelium; ct., connective tissue; plu., pleura. 200  $\times$ .
- B. Lung bud of a 13.5-mm. tadpole, showing earliest appearances of smooth muscle cells. musc., muscle cells; epith., epithelium; plu., pleura. 400  $\times$ .
- C. Cross section of the lung of a 40-mm. tadpole, showing condensed muscle sheet. musc., muscle; plu., pleura; ct., connective tissue; epith., epithelium.
- D. Cross section of the lung of a 46-mm. tadpole showing the formation of the rudimentary alveolar septa. pv., pulmonary vein; epith., epithelium; musc., muscle sheet; ct., loose connective tissue. 400  $\times$ .
- E. Cross section through the lung of a tadpole with hind legs, showing primitive alveolar septa. Length of tadpole, 56.0-mm. epith., epithelium; musc., muscle fibers; pv., pulmonary vein. 100  $\times$ .
- F. Cross section of the lung of a 60-mm. tadpole, taken near the distal end, showing the advanced condition of the musculature. pv., pulmonary vein; musc., muscle bundle; epith., epithelium; ct., loose connective tissue; plu., pleura.

muscle fibers. The anlage of the trachea has the same general structure but more posteriorly becomes somewhat flattened.

The lung buds consist of a single layer of very much flattened and somewhat spindle-shaped cells and are surrounded by very loose connective tissue. No signs of muscle cells are present. Fig. 3A.

By the time the tadpole has reached the length of 13.5 millimeters, muscle cells can be seen developing just under the epithelium. They form a single chain of spindle-shaped cells, which extend around the entire lung. The cells of the epithelium are still flattened, and a few scattered strands of connective tissue can be seen between the pleura and muscle cells. Fig. 3B.

One can best visualize this condition by imagining the lung as being composed of two sacs, exclusive of the plura, one fitting very closely

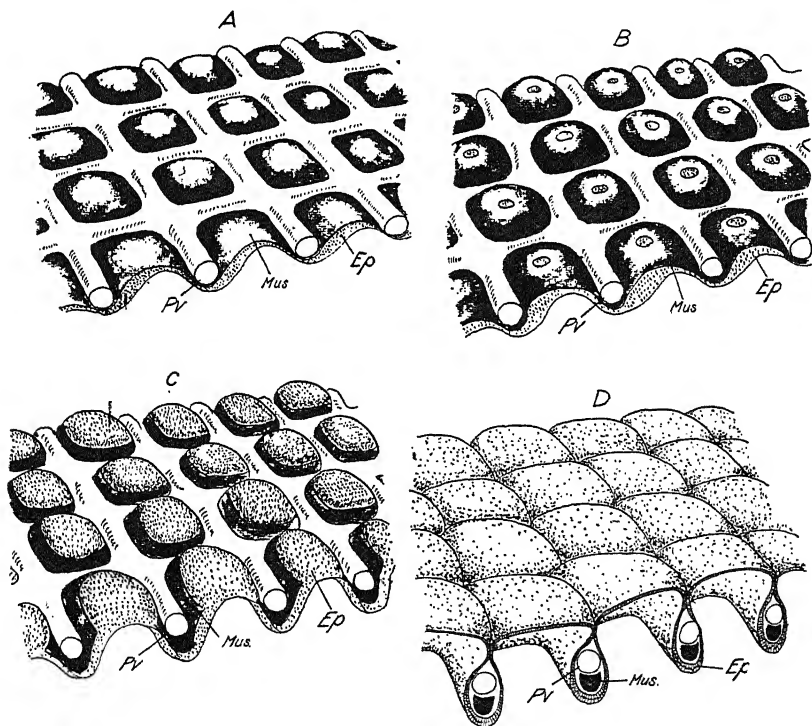


Fig. 4. Diagram showing the formation of the alveolar septa and internal musculature of the Anuran Lung.

- A. Lattice-like venous plexus of pulmonary vein with the epithelium and muscular sheets growing through the interstices.
- B. Perforations in muscle sheet, exposing the epithelial sheet.
- C. Perforations in muscle sheet increase as the muscle thickens over the veins.
- D. The muscle is completely condensed over the veins. The epithelium is grown together, forming alveolar septa.

Pv., pulmonary vein; Mus., muscle tissue; Ep., epithelium.

around the other. The inner sac is composed of evaginated endoderm, consisting of very much flattened cells. Around this sac, a second sac fits very closely and is composed of smooth muscle cells, which are loosely joined together.

Very little change can be noticed in the musculature of the lung until the tadpole has reached the length of 40.1 millimeters. At this stage, the muscle fibers have become condensed and extend throughout the interior of the lung just under the epithelium. The cells of the epithelium have become somewhat cuboidal. Fig. 3C.

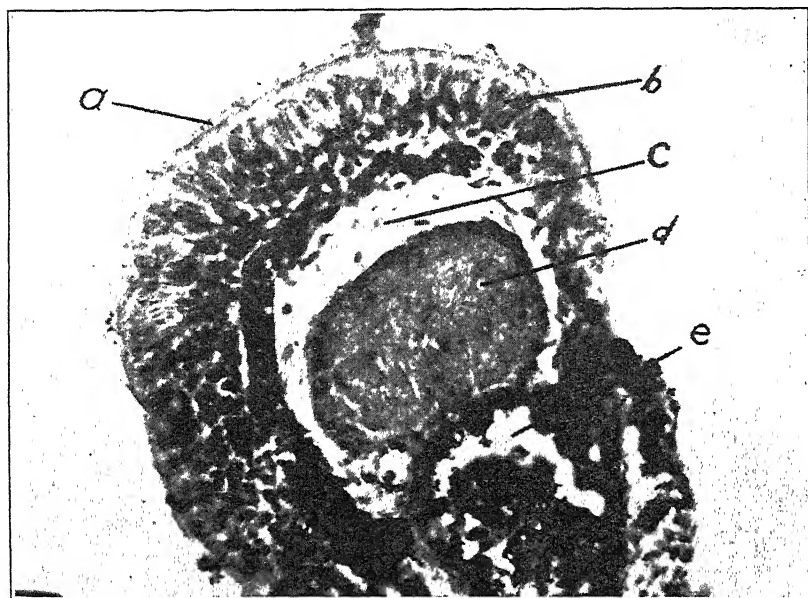


Fig. 5. Highly magnified view of a pulmonary vein and its associated structures: (a) cilia, (b) pseudo-stratified ciliated columnar epithelium, (c) loose white fibrous tissue, (d) muscle bundle, (e) lumen of vein containing India Ink and corpuscles. 800  $\times$ .

The veins can also be seen forming just under the muscle, their walls consisting of a single layer of endothelial cells. The connective tissue underlying the muscle strands is very loose. These veins form a rudimentary lattice-like plexus. The epithelium and muscle strands then grow into the openings of this lattice work. This leaves the veins surmounted by thickening muscle strands and epithelium extending as processes into the lumen of the lung cavity. This marks the first appearance of internal septa. Fig. 3D.

With the appearance of the hind legs, the muscular sac becomes thickened over the internal margins of the venous system. The muscular sac now ceases to be a sac, becomes perforated, and leaves a lattice-like muscular framework that remains permanently associated with the internal border of the venous plexus. Fig. 3E and Fig. 4.

It is interesting to notice that the sections, reading serially from the anterior to the posterior, show that the lungs become more developed toward the apex. This, at first glance, may appear quite contradictory to the well-established fact that an animal develops more rapidly at the anterior end than at the posterior end. However, it is to be remembered that the metabolic gradient, while higher at the anterior end of an organism than the posterior end, is also higher at the ends of the appendages. Thus it would seem logical for the apex of the lung to develop more rapidly than the root, since the lungs arise as appendages of the fore gut, and unless the anterior end remained in a more generalized condition, backward growth would be impossible.

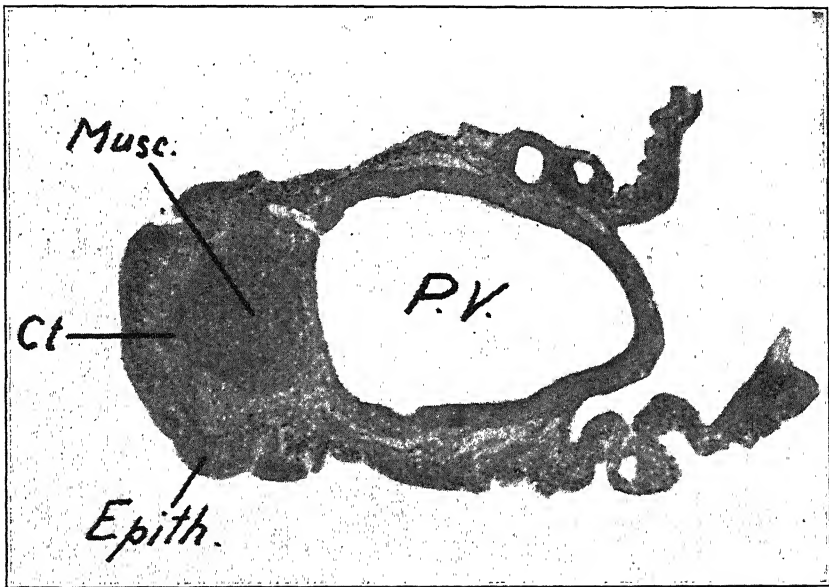


Fig. 6. Cross section through the pulmonary vein of the interior of the frog lung. *Musc.*, muscle bundle; *P. V.*, lumen of pulmonary vein; *Ct.*, connective tissue; *Epith.*, ciliated columnar epithelium.

Towards the apex of the same lung, as shown in Fig. 3E, the musculature, as well as the veins, has become very well developed. The epithelium is now approaching the columnar type, but it is still composed of a single layer of nonciliated cells which are not of the true columnar type as found in the adult organism. Fig. 3F.

Figure 5 shows a high-power photomicrograph of the vein with its connective tissue, muscle bundle, and pseudo-stratified ciliated columnar epithelium. The only comment necessary is that the muscle bundle is not the tunica media of the vein, but it is a structure which has developed in the mesoderm quite independently, and through growth has become very closely associated with it.



The main pulmonary vein, as shown diagrammatically in Fig. 2, when inside of the adult frog lung has the same structure as the other veins. A cross section taken through it shows that the vein and its associated muscles have developed in place and the epithelium has grown around them, leaving a raphae which is visible on the external surface of the lung when examined under high power with reflected light. Fig. 6 shows a photomicrograph through this vein in cross section.

#### SUMMARY

1. Cilia are found not only in the tracheal sacs at the root of the frog lung, but also on the free internal borders of all the numerous transverse and longitudinal septa.

2. The arteries and veins are not distributed as companions to one another, but independently, the arteries are restricted to the periphery and the veins are located on the extreme interior of the lungs, with the capillaries connecting these relatively widely separated vessels.

3. It is possible for the musculature to affect simultaneously both the intrapulmonic pressure and the venous return of the blood from the lung to the left auricle.

4. Embryonically the frog lung increases in complexity from the root to the apex.

5. The muscle bundle located beneath the epithelium of the alveolar septa is not a part of the tunica media, but is an independent structure, having developed as such, but in close association with the veins.

6. The alveolar septa are formed as follows:

- (a) A sac of endodermal epithelium, which has evaginated from the floor of the pharynx, becomes surrounded by a second closely fitting sac, composed of smooth muscle cells.
- (b) Around this second sac, a network of blood tubes develops and condenses into a lattice-like plexus of veins.
- (c) The epithelial and muscle sheets grow into the openings of this lattice work.
- (d) The muscle sheet thins and becomes perforated in the center of the lattice squares and thickens on the lung-cavity side of the veins.

#### LITERATURE CITED

- Arnold, Julius.** Vorläufige Mitteilung über das Epithel der Lungenalveolen. *Virchow's Arch.*, 1863, Bd. 27, S. 396.
- Zur Histologie der Lunge.** *Virchow's Arch.*, 1863, Bd. 27, S. 433.
- Bourne, G. C.** Comparative anatomy of animals. 1909, Vol. I, p. 42. London.
- Brown, T. G.** Die Atembewegungen des Frosches und ihre Beeinflussung durch die nervösen Zentren und durch das Labyrinth. *Arch. f. d. gesamte Physiol.* 1909, Bd. 130, S. 193.

- Carlson, A. J. and A. B. Luckhardt. Lung automatism and lung reflexes in the frog. I. Amer. Journ. Physiol., 1920, liv, p. 55.
- Cardiac and vasomotor reflexes induced by visceral stimulation in Amphibia and Reptilia. V. Amer. Journ. Physiol., 1921, lv, p. 31.
- Castroveijo, R. Modifications of differential stains with special reference to the trichromatic stain of Cajol. American Journal of Clinical Pathology, 1932, ii, No. 2.
- Fedrow, V. Ueber die Entwicklung der Lungenvene. Anatomische Hefte, 1910, xl, S. 533-603.
- Gaupp, E. Zur Lehre von dem Athmungsmechanismus beim Frosch. Arch. f. Anat. (u. Physiol.), 1896, S. 329.
- Histologischer Bau der Lungenwandung. Ecker u. Wiedersheim's, Anatomie des Frosches, 1904, Abt. 3. Braunschweig. S. 196.
- Gegenbaur, Carl. Vergleichende Anatomie der Wirbelthiere, 1901, Bd. 2, S. 300, Leipzig.
- Greil, Alfred. Über die Anlage des Lungen, Sowie der Ultimobranchialen (Post-branchialen, Supraperikardialen) Körper bei Anuren Amphibien. Anatomische Hefte, 1905, Band 29, Hefte 3, S. 447-506.
- Haslam, G. Ecker's, Anatomy of the frog. 1889. p. 317. Oxford.
- Hoffman, C. K. Bronn's, Klassen und Ordnungen des Thierreichs. 1878. S. 514. Leipsig U. Heidelberg.
- Holmes, S. J. Biology of the frog. 1927. 4th ed., p. 165. New York. The MacMillan Co.
- Königstein, Hans. Die Function der Muskelatur in der Amphibienlunge. Arch. f. d. gesamte Physiol., 1903, Bd. 95, S. 616.
- Küttner, Dr. Beitrag zu den Kreislaufverhältnissen der Froschlunge. Virchow's Arch., 1874, Bd. 61, S. 21.
- Luckhardt, A. B., and A. J. Carlson. Lung automatism and lung reflexes in the salamanders. II. Amer. Journ. Physiol., 1920, liv., p. 122.
- Lung automatism and lung reflexes in *Cryptobranchus* with further notes on the physiology of the lung of *Necturus*. VI. Amer. Journ. Physiol., 1921, lv, p. 212.
- On the presence of vasomotor fibers in the vagus nerve to the pulmonary vessels of the Amphibian and the Reptilian lung. VIII. Amer. Journ. Physiol., lvi, p. 72.
- Miller, W. S. The structure of the lung. Journ. Morph., 1893, viii, p. 165.
- Oppel, Albert. Die Lunge. Lehrb. d. vergl. mikrosk. Anat. d. Wirbd. 1905, Bd. 6, S. 265, Jena.
- Renaut, J. Traite d'histologie pratique. 1897. T. 2, Fasc. 1. p. 488, Paris.
- Thomson, J. A. Outline of zoology. 1899. 3rd ed., p. 546. New York.
- Waterman, F. A. A dioxan method for triple staining. Stain Technology, 1937, xii, 21-23.
- Wiedersheim, R. Die Lungen. A. Ecker's, Anatomie des Frosches, 1882. Abt. 3, S. 33. Braunschweig.
- Winterstein, Hans. Haut- und Lungenatmung. Handb. d. vergl. Physiol., 1921, Bd. 1, Hft. 2, S. 191. Jena.

### Marine Mollusca

This little booklet of 87 pages,  $5\frac{1}{2} \times 8\frac{1}{2}$  inches, clearly printed and bound in heavy paper covers, should prove valuable to the student of marine Mollusca anywhere, and not merely on our Pacific coast. Data concerning distribution of the species increase the usefulness of the check list. The bibliography is so selected and organized as to be of greatest possible help to the beginner in this field.

—W. J. Kostir.

An Abridged Check List and Bibliography of West North American Marine Mollusca, by A. Myra Keen. 87 pages. Stanford University, California, Stanford University Press, 1937. \$1.50.

STUDIES OF THE GENUS EMPOASCA  
(HOMOPTERA, CICADELLIDAE)

PART VI

TWENTY-TWO NEW SPECIES OF EMPOASCA  
FROM NORTH AMERICA

RALPH H. DAVIDSON

AND

DWIGHT M. DELONG

Ohio State University

*Empoasca necyla* n. sp.

Resembling *birdii* in appearance and coloration but with lateral processes as in *radiata* and a dorsal spine as in *spira*. Length 4 mm.

External characters: Vertex produced and bluntly angled. Color yellowish with a median pale longitudinal line, and a basal oblique pale spot on either side. Pronotum with three pale spots on anterior margin. Scutellum with a median longitudinal stripe, and apical third pale. Claval area and sometimes a transverse spot across disc of elytron dark brown in color. Female segment roundedly produced.

Internal male genitalia: Lateral processes long, and slender, apex pointed and curved sharply outwardly, but when crossed before apices these curved tips are directed toward each other. Dorsal spine appearing transverse, directed caudally on basal portion, abruptly bent ventrally and gradually, evenly, narrowed to a curved, medially directed, long slender apex.

Holotype male, allotype female, and male and female paratypes from Warren, Illinois, Aug. 28, 1934 (Frison and DeLong), in collection of the Illinois State Natural History Survey. A male and female paratype in collection of authors.

*Empoasca curvexa* n. sp.

Resembling *recurvata* in shape of lateral processes but with distinctly characteristic spines. Length 3 mm.

External characters: Vertex bluntly produced and rounded. Color dull green, tinged with golden yellow. Apices of elytra subhyaline.

Internal male genitalia: Lateral processes abruptly curved dorsally at three-fourths their length resembling the lateral processes of *recurvata*. Dorsal spines long, curved ventrally, broad to near apex where they are rather rapidly narrowed to pointed apices. This species can be distinguished from *recurvata* by the spine character.

Holotype male from Edgewater, Florida, April 6, 1938 (DeLong) deposited in the authors' collection.

***Empoasca dorothyi* n. sp.**

Resembling *elongata* in general appearance with lateral processes somewhat like *galluxa* and a characteristic dorsal spine. Length 3.5 mm.

External characters: Vertex rather strongly, bluntly produced, color dull yellow, with a pale spot at apex of vertex, a median pale line and a pale spot next either eye on anterior margin. Pronotum with three pale spots on anterior margin. Apical third of scutellum pale. Elytra golden yellow, subhyaline.

Internal male genitalia: Lateral processes rather short, slightly enlarged on median third, slender at apex, curved caudally and dorsally. Dorsal spines broad at base with a rounded lobe posteriorly, then abruptly curved and narrowed on posterior margin to form a ventrally directed narrow spine at apex.

Holotype male, and paratype male from Oak Creek Canyon, Arizona, Aug. 1, 1938 (Knull) and a male paratype from Flagstaff, Arizona, July 30, 1938 (Knull). Types in the Ohio State University collection and the authors' collection.

The authors take pleasure in naming this species in honor of Dorothy Johnson Knull who has collected and described many interesting Cicadellidae.

***Empoasca knulli* n. sp.**

Resembling *similis* in form and general appearance, with lateral process as in *similis* and a spine as in *bicuspidata*. Length 3 mm.

External characters: Vertex broadly rounded, only slightly produced before anterior margins of eyes. Color yellowish green, a median pale line on vertex and an oblique dash at base on each side. Three spots on anterior margin of pronotum, and a broad, pale, longitudinal band on scutellum. Elytra smoky green, veins pale.

Internal male genitalia: Lateral processes broadened on median third then tapered to acutely pointed, slender tips. Dorsal spines broad at base, extending caudally, curved ventrally and narrowed to a bifurcate apex. The anterior spine slightly longer than the posterior and the two are separated by a V-shaped notch. Aedeagus broad, curved slightly caudad and then dorsad.

Holotype male from Huachuca Mts., Arizona, Sept. 9, 1938. (Knull), deposited in the authors' collection.

This species is named in honor of Prof. J. N. Knull who has collected so many interesting undescribed species in the Cicadellidae and many other groups.

***Empoasca manda* n. sp.**

Resembling *plebeia* somewhat in general form and appearance but with distinct genital characters. Length 3 mm.

External characters: Vertex broadly rounded, bluntly produced. Color pale green tinged with yellow.

Internal male genitalia: Lateral processes long, widened on outer margins just before apex to form rounded lobe-like structures, then narrowed abruptly to form finger-like processes on inner margins, the apices of which are slender and waved. Dorsal spines directed ventrally,

rather broad, abruptly and strongly rounded at apex forming structure as in *tamiama*.

Holotype male from Dade County, Florida, collected in March, 1938, (Fisk) and deposited in the authors' collection.

### ***Empoasca pinella* n. sp.**

Resembling *ponderosa* in form and general appearance, with processes on aedeagus and dorsal spine somewhat as in *coccinea*. Length 3.7 mm.

External characters: Vertex strongly produced, but apex blunt. Vertex, pronotum, and scutellum sordid green tinged with golden yellow. Elytra smoky, often appearing almost black. Face sordid green. Female segment roundedly produced.

Internal male genitalia: Aedeagus with the two proximal long slender processes arising at base as in *coccinea*, but not as heavy nor as deeply notched. Body of aedeagus erect, apical end forming a broad sickle-shaped blade. Dorsal spine broad at base, constricted abruptly to narrow pointed process which is directed downwardly.

Holotype male, allotype female, and male and female paratypes from San Franc. Mts., Arizona, Aug. 12, 1929 (Ball); male and female paratypes from Chiricahua Mts., Arizona (Ball), July 5, 1930, and Tucson, Arizona, Sept. 1, 1929 (Ball). Types in the Ball collection except for male and female paratypes in the collection of the authors.

### ***Empoasca nema* n. sp.**

Resembling *erigeron* in form and general appearance but with distinctly different lateral processes. Length 3-3.5 mm.

External characters: Vertex broadly bluntly angled. Color, dull green to golden yellow. Vertex usually unmarked, pronotum with three white spots on anterior margin. Scutellum with central portion and apical third pale. Elytra tinged with golden yellow. Female segment roundedly produced.

Internal male genitalia: Lateral processes similar to *erigeron* in shape, narrowed on inner margin to form slender, finger like processes on outer margins. Dorsal spine broad on basal portion, bent abruptly and curved ventrally at caudal margin and narrowed to a long slender apex which is directed anteriorly. Aedeagus erect with a rather long and widened process arising caudally near apex and directed dorsally and caudally.

Holotype male, allotype female, and male and female paratypes from Oak Lawn, Illinois, July 1, 1935 (DeLong and Ross). Male and female paratypes from Alsip, Illinois, Aug. 23, 1934, (DeLong and Ross) and from Des Plaines, Illinois, Sept. 18, 1935, (DeLong and Ross). All types in collection of Illinois State Natural History Survey except for a male and female paratype in the DeLong Collection and the Ohio State University collection.

### ***Empoasca sagitta* n. sp.**

Resembling *dentata* in form and general appearance but with characteristic dorsal spine. Length 3.7 mm.

External characters: Vertex strongly produced, conical, apex blunt, color dull yellow without definite markings. Elytra subhyaline.

Internal male genitalia: Lateral processes long, slender, touching just before apical portions which are strongly bent outward and pointed at tips. Dorsal spines broad at base tapered to curved slender apical hooks which are curved caudally dorsally and inwardly. Aedeagus slender, a rather long, broad caudal portion arising near middle and extending dorsally and caudally.

Holotype male from White Pine Forest Park, Illinois, July 12, 1934 (DeLong and Ross) and deposited in the collection of the Illinois Natural History Survey.

### ***Empoasca strangula* n. sp.**

Resembling *obtusa* in form and general appearance but with distinct lateral processes. Length 4 mm.

External characters: Vertex broadly rounded, parallel margined, scarcely produced. Color reddish brown, elytra subhyaline.

Internal male genitalia: Lateral processes appearing slightly concavely notched on ventral side at apex forming a very short blunt process on dorsal margin. Dorsal spines rather large at base with a ventral pointed spur beneath basal portion, the remainder sickle-shaped with the blade strongly curved and tapered to a very slender apex, which is ventrally curved and anteriorly pointed.

Holotype male from Redfish Lake, Idaho, Aug. 3, 1930 (DeLong) and a male paratype from Galena, Illinois, June 28, 1935 (DeLong and Ross). Holotype in the DeLong collection; paratype in the Illinois Natural History Survey Collection.

### ***Empoasca thela* n. sp.**

Resembling *dilitara* in form, general appearance, and shape of lateral processes. Length 3 mm.

External characters: Vertex broad, bluntly produced. Color sordid green tinted with golden yellow. Elytra dull green subhyaline. Female segment concavely rounded either side of a central lobe.

Internal male genitalia: Lateral processes enlarged on apical two-thirds to apex which is abruptly narrowed on ventral margin forming a curved, slender finger-like process. Dorsal spines, short and broad, directed ventrally, almost straight on anterior margin, strongly convex on posterior margin to form a bluntly pointed apex. Aedeagus erect, a long sickle-shaped process very broad at base, arising on caudal margin at apex, and a long slender process on each side just below base of the larger process. These structures are curved caudally and then dorsally from point of attachment.

Holotype male (Nov. 22, 1910), allotype female (Dec. 6, 1910) and female paratype (Dec. 6, 1910) from Brownsville, Texas. One female paratype from Katherine, Texas, Dec. 3, 1911, and a series of male and female paratypes from Brownsville, Texas, Aug. 8, 1937 (Knull), all deposited in the collections of the authors and the Ohio State University.

***Empoasca ocala* n. sp.**

In general appearance resembling pale specimens of *fabae* but male genital characters more like *ancistra*. In the latter species the lateral processes of male are slender before the inwardly curved portion and the dorsal spine is not gradually tapered to slender apex. Length 2.5 mm.

External characters: Vertex produced and bluntly angled, color yellowish or pale green. Two greenish spots on disc of vertex. Female last ventral segment roundedly produced.

Internal male genitalia: Lateral processes long, in lateral view appearing rather broad, definitely widened just before apical third which is strongly curved inwardly and abruptly narrowed, the two processes contiguous and curved outwardly to form rather long slender apices which are divergent and directed laterally. Dorsal spine sickle-shaped, rather broad at base, curved, gradually narrowed to slender apical third which is directed anteriorly.

Holotype male, allotype female, and a large series of male and female paratypes from Ocala Forest, Silver Springs, Florida, collected March 20, 1938 (DeLong). Types in the collections of the authors and the Ohio State University.

***Empoasca mesolinea* n. sp.**

Resembling *osborni* in general form. Smoky, marked with a median pale line across vertex, pronotum, and scutellum. Length 3.5 mm.

External characters: Vertex broadly rounded, parallel margined. Face with a dark brown band on either side between which is a pale median line that continues across vertex, pronotum and scutellum. A pale spot on pronotum behind each eye. Elytra dark greenish, a smoky line along commissural line with claval suture brownish. Apices of elytra smoky. Female segment roundedly produced.

Internal male genitalia: Lateral processes long, enlarged near apex and in ventral view with a finger process on inner margin of enlargement. In lateral view clavate, appearing to have a terminal curved finger process arising from apex of the rounded, enlarged apical portion. Dorsal spines rather heavy at base directed caudad then ventrad, tapering from base to form long slender spines. Aedeagus directed dorsad, terminal third erect, ovate, with a short anterior spine at base.

Holotype male and allotype female from Huachuca Mts., Arizona, July 20, 1937 (Knull) in authors' collection.

***Empoasca amara* n. sp.**

Resembling *radiata* in coloration but paler and with vertex more bluntly angled. Length 3.5 mm.

External characters: Vertex bluntly angled only slightly longer at middle than next the eyes. General coloration, green marked with orange. Vertex and pronotum dull green mottled with orange; basal angles of scutellum orange. Elytra pale, with three light orange longitudinal stripes, one each on clavus, costal area and corium, while in some specimens these areas are entirely orange. Apices smoky, veins pale. Female last ventral segment roundedly produced.

Internal male genitalia: Lateral process long, slender, apices very narrow, curved outwardly, divergent. Dorsal spine short, basal half broad, transverse apical half directed ventrad, tapered rapidly to a slender pointed apex. Aedeagus enlarged on apical third with a pair of short spines at base of enlargement. These spines are directed posteriorly and the tips are slightly curved upwardly.

Holotype male, allotype female, and a large series of male and female paratypes from Davis Mts., Texas, June 2, 1937, and Sept. 20, 1938, (Knull) in the authors' collection and the Ohio State University collection.

***Empoasca kaibaba* n. sp.**

Resembling *medora* in general appearance but with lateral processes as in *recta* and dorsal spine somewhat like *pelecana*. Length 3-3.5 mm.

External characters: Vertex broad, blunt, slightly produced. Color yellowish tinged with orange. Elytra dull golden iridescent, the veins pale, causing them to appear striped. Female last ventral segment roundedly produced.

Internal male genitalia: Lateral processes simple, a little longer than styles, apices pointed. Dorsal spines short, broad, anterior margin slightly concave; posterior margin more strongly rounded to form pointed ventral apex. Aedeagus erect, apical portion branched, an arm extending from both sides to dorsal spines, and a rather long slender caudal portion produced caudad and dorsad.

Holotype male, allotype female and female paratype from Kaibab, Utah, June 21, 1937. Also male and female paratypes from Flagstaff, Arizona, June 23, 1937, and June 28, 1937, all collected by D. J. and J. N. Knull. Types in the authors' collection and the Ohio State University Collection.

***Empoasca uvalda* n. sp.**

A small species, resembling *bifurcata* and *bicuspidata* in general appearance, but with characteristic lateral processes somewhat like those of *spira*. Length 3 mm.

External characters: Vertex produced and bluntly angled; colored dull green, with a median, pale, longitudinal stripe and a pale spot on disc of either side. Three pale spots on margin of pronotum. Elytra rather uniformly golden green, apices slightly smoky. Female last ventral segment roundedly produced.

Internal male genitalia: Lateral processes slender bent abruptly ventrally near apices which are pointed. Dorsal spines broad at base, apical half sickle-shaped, directed ventrad and rapidly narrowed to slender pointed apex. Aedeagus erect, apex with bifurcate arms and a caudal projection near apex.

Holotype male, allotype female and male paratype, from Brownsville, Texas, Aug. 8, 1937, (Knull) and male and female paratypes from Uvalde, Texas, Aug. 4, 1937, (Knull). Types in the authors' collection and the Ohio State University Collection.

***Empoasca ancistra* n. sp.**

Resembling *recurvata* in general appearance but with vertex more produced and lateral processes somewhat as in *radiata*. Length 2.5 mm.



External characters: Vertex distinctly produced but bluntly angled. Color apple green marked with darker green to brownish. Elytra dusky, venation paler, marked with longitudinal streaks of brownish pigment of variable intensity between the veins. Apices of elytra dusky. Last ventral segment of female roundedly produced.

Internal male genitalia: Lateral processes tapered to slender apical portions which are strongly bent outwardly near apices. Dorsal spines short, basal half widened and directed caudad, apical half directed ventrad and tapered to a very slender tip.

Holotype male and allotype female from Oak Creek Canyon, Arizona, Aug. 15, 1938 (Knull). Male paratypes from Huachuca Mts., Arizona, July 20, 1937 (Knull). Types in the authors' collection and the Ohio State University Collection.

### ***Empoasca hecta* n. sp.**

Resembling *cerea* in form and general appearance but with distinct lateral processes and a dorsal spine which resembles that of *decora*. Length 2.75 mm.

External characters: Vertex bluntly produced, of sordid green color with a faint median line and a pale spot next each eye at base. Pronotum with a row of pale spots along anterior margin. Elytra with apices smoky, veins pale.

Internal male genitalia: Lateral processes short, tapered to slender, straight apices. Dorsal spines rather broad at base extending caudad, apical third more slender, curved ventrad, blunt at apex and rounded. Aedeagus erect, three caudal processes arising about middle. The central process is longer and is directed more dorsad than the lateral shorter pair.

Holotype male from Davis Mts., Texas, Sept. 20, 1938 (Knull) and a male paratype from the same locality collected Aug. 2, 1937. Types in authors' collection and the Ohio State University Collection.

### ***Empoasca madra* n. sp.**

Resembling *diverta* in general coloration, but larger in size and with more produced head. Lateral processes resembling those of *amara*. Length 3 mm.

External characters: Vertex strongly produced and bluntly angled. Color of vertex brownish green with a median pale longitudinal line, a pale spot around each ocellus and a larger one at the base next either eye. Pronotum with a pale spot behind each eye and a pale spot at middle. Apical half of scutellum pale. Elytra smoky tinged with green; basal portion, spots on clavus, and apical third brown. Veins of apical portion paler in color.

Internal male genitalia: Lateral processes long, slender, apical fourth slender and strongly curved laterad, then gently curved dorsad. Dorsal spine broad on basal half which is directed caudad at the apex of which it curved to slender apical, ventrally directed half.

Holotype male from Huachuca Mts., Arizona, collected July 20, 1937, (Knull). Type in authors' collection.

***Empoasca galluxa* n. sp.**

Resembling *ancistra* in general form and appearance, but with distinct lateral processes and a dorsal spine somewhat like that of *ratio*. Length 3 mm.

External characters: Vertex strongly produced and bluntly pointed. Color pale yellowish, mottled with paler yellow, a darker stripe extending from base to apex of elytron just anterior to claval suture. Last ventral segment of female roundedly produced.

Internal male genitalia: Lateral processes short, slender, only a little longer than styles, gently curved dorsad. The tips of these processes are gently, concavely notched on inner margin. Dorsal spines broad at base deeply roundedly notched on anterior margin forming a ventrally directed rounded lobe from the anterior apical portion of which arises a narrow finger-like spine directed anteriorly and curved ventrad.

Holotype male and allotype female from Santa Rita Mts., Arizona, July 13, 1937, (Knull) and male and female paratypes from Huachuca Mts., Arizona, July 20, 1937, (Knull). Types in authors' collection and the Ohio State University Collection.

***Empoasca utrica* n. sp.**

Resembling *birdii* in general appearance and coloration but with dorsal spines roundedly inflated at base and with distinct lateral processes. Length 4 mm.

External characters: Vertex bluntly angled, produced before margins of the eyes. General coloration, pale yellow. Vertex with a pale marking at apex connected with a median pale line and with two oblique dashes at base. Pronotum with three pale spots on anterior margin. Scutellum with a broad median pale band. Elytra with claval area sometimes brownish.

Internal male genitalia: Lateral processes long, rather broad at base, concavely narrowed on outer margin to slender processes which are enlarged at three fourths their length by slightly convexly rounded outer margins, then tapered to pointed apices. Dorsal spine roundedly inflated dorsally at base, curved to apical half which is slender and directed ventrally and slightly anteriorly.

Holotype male from Poudre R. Canyon, Colorado, Aug. 22, 1931, (Beamer), and a male paratype from Republic, Washington, Aug. 6, 1931, (Beamer). Holotype in the collection of Dr. R. H. Beamer and paratype in authors' collection.

***Empoasca tamiamia* n. sp.**

Resembling *bifurcata* in coloration and general appearance but with blunter vertex and a short, bluntly rounded, lobe-like spine. Length 3.5 mm.

External characters: Vertex strongly produced and bluntly angled. Color green tinged with golden yellow, a pair of round green spots on disc of vertex. Female segment broadly angularly produced.

Internal male genitalia: Lateral processes resembling those of *ziona*, being long, straight, with apices slightly concave on upper margins. Aedeagus in lateral view broad, erect, apex truncate, with a rounded

notch on anterior margin near apex. A long heavy spine arises on posterior margin near base which is erect and curved caudad at the middle and extends to the apex of the pygofer. Dorsal spines short, rather broad, directed ventrad and rounded at apex somewhat as in *solana*.

Holotype male, allotype female, and a large series of male and female paratypes from Tamiami Trail, Florida, March 31, 1938, (DeLong). Types in the authors' collection and the Ohio State University Collection.

### ***Empoasca gampoia* n. sp.**

Resembling *elongata* in general form but with characteristic shape of lateral processes and dorsal spine. Length 4 mm.

External characters: Vertex distinctly produced and bluntly rounded, with a T-shaped mark, the top of which is at the apex and a pale spot on each side near the base next to each eye. Yellowish to greenish in color, apical third of scutellum paler. Elytra subhyaline tinged with golden yellow. Female segment roundedly produced.

Internal male genitalia: Lateral processes rather long narrowed on apical fourth which is bent laterad. These are usually crossed one third this distance from apex so that the apices are proximal and convergent. The tips of these processes are flattened and enlarged, appearing pad-like. Dorsal spines broadened from base, the caudal ventral angle strongly rounded. The anterior ventral angle strongly curved mesad and ventrad and slightly twisted to form a rather short apical spine. Aedeagus erect with the caudal process bifurcate at apex.

Holotype male, allotype female, and male paratype from Graham Mts., Arizona, Aug. 28, 1933 (F. H. Parker). One male paratype from Pinal Mts., Arizona (Parker), three female paratypes from Huachuca Mts., Arizona, July 20, 1937, (Knull), and three male paratypes from Oak Creek Canyon, Arizona, Aug. 1, 1938, (Knull). Types in the authors' collection and the Ohio State University Collection.

---

### **A Bibliography of Statistical Methods**

The author of this book (or more strictly speaking, the editor) has had much success in the past in compiling bibliographies on various educational, psychological and personality tests. He has now turned his attention to research and statistical methodology. The result is a rather complete compilation of books, from 1933 to 1938, on this subject, covering actuarial mathematics, agriculture, biology, business, economics, education, engineering, forestry, history, marketing, medicine, psychology, sociology and vital statistics. For each book there is given a series of critical reviews culled from various scientific journals both here and abroad. The books are listed alphabetically by author; in addition there are various indexes, including a classified index, an index of titles and an index of authors and reviewers. The evaluations cover books published in many countries, thus making this compilation an extremely valuable source of reference to anyone engaged in the design and execution of experiments.—L. H. S.

**Research and Statistical Methodology Books and Reviews of 1933-1938**, edited by Oscar Krisen Buros. vi+100 pp. New Brunswick, N. J., Rutgers University Press, 1938. \$1.25.

## DIURNAL ACTIVITY RHYTHMS IN FRESH-WATER FISHES

WARREN P. SPENCER,  
College of Wooster

### INTRODUCTION

Rhythmic phenomena involving the orderly recurrence of events are characteristic of inanimate nature. Many of the activities of plants and animals are also marked by physiological rhythms. Their tempo may be extremely rapid as in volleys of nerve impulses passing along a nerve fiber, the heart-beat, or ciliary activity. In such cases the rhythm seems to be determined by a discharge-recovery mechanism associated with the physico-chemical nature of the process. Other activity rhythms have a longer cycle, sometimes of days or even months duration. The physiological rhythm may coincide in time with a rhythmic phenomenon in the physical environment in such a way as to leave little doubt that there is a relationship between the two. Among the commonest of these are activities of plants and animals correlated with the 24-hour cycle and known as diurnal rhythms.

The diurnal-nocturnal fluctuation in light intensity and temperature would be expected to affect certain physiological processes directly and others indirectly. But in some cases when these factors are held constant the physiological rhythm persists over long periods of time. These are then referred to as "innate" rhythms. However, little is known as to whether such phenomena are acquired or racial characters. It is not our intention here to review the literature on diurnal rhythms. The reader is referred to a recent review of the subject by Welsh (1938).

General activity, the sum total of the gross body movements of an animal, is a rough measure of the metabolic rate and can in turn be measured over longer or shorter time intervals

by the use of appropriate apparatus. Szymanski, a pioneer in this field, (1914, 1919) has studied activity in many species of animals by the use of ingenious devices which he designates "actographs." Under conditions as nearly normal as the experimental method would allow he has shown that the activity rhythms of different organisms tend to fall into two general classes. The first class includes those forms which in a 24-hour cycle show a single sustained period of activity followed by one of absolute or relative rest. Such a cycle he designates as "monophasic." In a second type more than one period of activity alternate with a corresponding number of rest periods in a 24-hour cycle. From a consideration of the data Szymanski concludes that the monophasic organisms have their behavior pattern largely influenced by visual stimuli, while in "polyphasic" forms vision plays a role secondary to gustatory, olfactory, or other stimuli.

The most complete study of nocturnal-diurnal rhythm which has come to our attention is that of Johnson (1926) on the forest deer-mouse. By prolonged observations, using a quantitative recording device, he has demonstrated an innate rhythm in this animal with a period of increased activity at night. This was shown to persist even in total darkness. Other experiments have demonstrated the persistence over considerable periods of time, even under constant light and temperature, of activity rhythms of the monophasic type in various species of animals. The data in this field indicate that there is present a rather deeply established 24-hour rhythm in certain animals, but that this may sometimes be altered by external stimuli. This alteration does not, of course, answer the question as to whether the rhythm is an acquired or an inherited one.

We shall here report a series of preliminary experiments dealing with total activity over periods of from one to several days duration in ten species of fresh-water fish. In all 32 specimens were used and quantitative records totaling 267 days and 8 hours were secured.

#### APPARATUS AND METHODS

Some years ago in the course of studies on the lateral line nerve of the goldfish in the laboratory of animal behavior at the Ohio State University it became apparent that a method of securing quantitative data on total activity would be of

advantage. The apparatus shown in Figure 1 and described under the name of "ichthyometer" (Spencer, 1929) was designed to meet this need. It consists of an extremely light lever, with an adjustable counter-weight on the short recording arm. To the end of the long arm a thread is attached which runs through a rigid screw-eye, fixed about half an inch above the water at one end of the experimental tank. This thread is attached to the dorsum of the fish near the tail by a loop of thread or light aluminum wire. The counter-weight is so adjusted that the short arm is slightly heavier than the long arm, but a pull of approximately one gram will move the lever

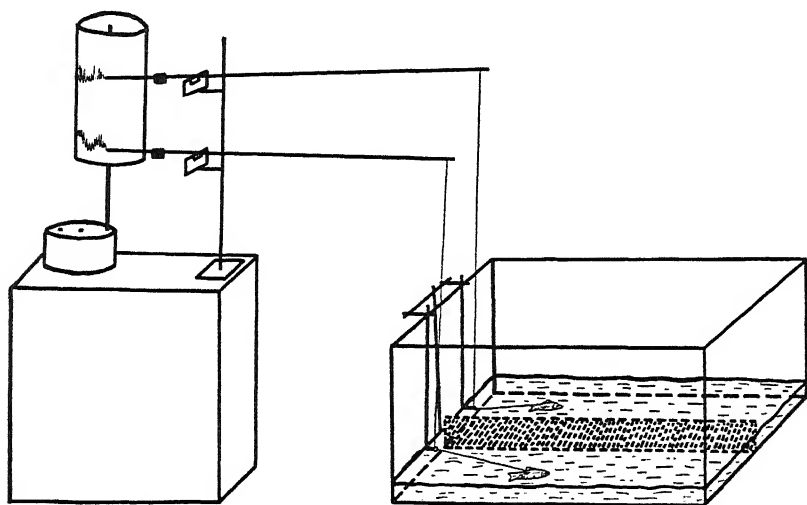


FIGURE 1

as the fish swims away from the end of the tank. Slack in the thread is quickly taken up as the fish swims toward the apparatus. The recording arm writes the record on a slow-kymograph. Time intervals of one hour were marked on the records taken. This was done in the early experiments by marking off the total time interval into parts of one hour when the record was removed, on the assumption that the drum revolved at constant speed. In later experiments an automatic timing device marking one hour intervals was used.

This apparatus not only records the total activity, but also the activity pattern, for in a long tank such as used the graphic record indicates the position of the fish in the tank at all times.

With fishes three inches or more in length direct observation shows that the fish swim about normally, feed and react to stimuli as do other fish in the aquarium. The "actograph" for fish devised by Szymanski consisted of a pulley-wheel suspended from a spring lever. Over the pulley-wheel ran a thread with a fish attached at one end and a weight at the other. This device gave only a rough measure of activity through the agitation of the lever caused by the thread running over the pulley-wheel, and did not record the activity pattern.

Polimanti (1911) made extensive observations on many of the marine fishes at the Zoological Station at Naples. His method, that of direct observation, is valuable in contributing to the knowledge of the habits and reactions of fish. Obviously it is not entirely satisfactory, particularly at night, where the use of light might conceivably disturb the normal behavior pattern.

Our data with experimental procedure involved can best be presented separately for each species or group of species studied: the Centrarchidae, the carp, the mud-minnow, the goldfish, and a few other fishes.

#### THE CENTRARCHIDAE

All records on the Centrarchidae were secured at the Stone Laboratory of the Ohio State University, Put-in-Bay, Ohio, during the summers of 1929 and 1932. The apparatus was set up in a dark basement room, with a little light filtering in during the day and temperature of about 21° C. The aquarium used was approximately 24 inches long, and divided by an opaque partition down the center into two tanks each about 7 inches wide. Water pumped from the lake circulated slowly through the tanks. The fish were fed on earthworms, crustacea and small fish and readily took food while attached to the apparatus.

Records were taken simultaneously on a rock-bass, *Ambloplites rupestris*, and a sunfish, *Eupomotis gibbosus*, from 6:00 P. M. July 20th to 8:30 A. M. July 23rd. A sample record of the sunfish is shown in Plate I. Throughout the experiment the sunfish was active by day. At night from about 8:00 or 9:00 P. M. until about 5:00 A. M. there ensued a period of almost total quiescence. The records of the rock-bass showed no such periodic fluctuation. This fish swam more than the sunfish at night and less by day. These data are of particular

interest in connection with what is known of the feeding habits of the two. Rock-bass may be caught at almost any hour of day or night, while it is not the usual thing to catch sunfish at night.

Two blue gills, *Lepomis pallidus*, approximately 6 inches long, were studied in July, 1932. Continuous records of two days duration were taken for each. These showed that both specimens swam day and night with no apparent diurnal variation, and that they were somewhat more active than the rock-bass.

Records on two large-mouth black bass, *Micropterus salmoides*, taken in July, one for a little over a day and the other for two days, showed continuous swimming with a period of lessened activity rather poorly defined between 1:00 and 5:00 A. M. The fish used were a little over 6 inches long.

Of the Centrarchids studied it may be concluded that the sunfish showed a very clearly defined 24-hour rhythm, the black bass a poorly defined one, rock-bass and blue-gills none. The sunfish was least active, the rock-bass intermediate, and blue-gills and black bass most active. The data are too fragmentary to be of much value in determining relative amounts of activity, but do give some information on the pattern for the different species.

#### THE CARP (*Cyprinus carpio*)

During the summer of 1929 activity records were taken at the Stone Laboratory on three young carp each about 4 inches long. These were individuals from the spring hatch. The fish were kept in a still-water aquarium in a basement room, well lighted by day and with some artificial light entering at night until 10:00 P. M. from lights outside the laboratory. The tank was approximately 24 inches by 7 inches with water 4 inches deep. The temperature remained close to 21° C. with little fluctuation from day to night. The experiments on these fish covered a total period of 7 days and 13 hours during the latter part of July and early August. All records showed a period of intense activity during the night followed by lessened activity in the day. The carp at this age are very active night swimmers with a clearly defined monophasic pattern. A sample activity graph appears in Plate I. Table I gives the approximate times of the beginning and end of each period of hyperactivity.



Two larger carp, each  $9\frac{1}{2}$  inches long, were secured in the summer of 1932 and records taken on them over a period of about 4 days. These fish were a year older than the first ones used. In carp No. 4, the larger of the two specimens (greatest depth 3 inches) the record, continued over 43.4 hours, showed a total lack of the diurnal rhythm so apparent in younger specimens. Carp No. 5 (greatest depth  $2\frac{3}{4}$  inches) showed a tendency to swim more by night than by day, but the cycle was not as well defined as in the younger fish. These records were taken in the latter part of July. The records indicate clearly a change in activity pattern with age in the carp. The

TABLE I  
NOCTURNAL DRIVE IN YOUNG CARP

Fish No.	Begins	Ends	Duration in Hours
1	10:30 P. M. July 28.....	4:45 A. M. July 29.....	6.25
1	10:00 P. M. July 29.....	5:15 A. M. July 30.....	7.25
1	11:30 P. M. July 30.....	4:50 A. M. July 31.....	5.33
1	10:15 P. M. Aug. 1.....	4:15 A. M. Aug. 2.....	6.00
2	10:00 P. M. Aug. 10.....	4:45 A. M. Aug. 11.....	6.45
3	8:30 P. M. Aug. 11.....	8:30 A. M. Aug. 12.....	12.00
3	7:30 P. M. Aug. 12.....	6:20 A. M. Aug. 13.....	10.83
3	5:30 P. M. Aug. 13.....	6:30 A. M. Aug. 14.....	13.00

carp, often thought of as lazy and sluggish, when measured in terms of total movements over a long period, is among the most active of the fishes studied. This seems correlated with its foraging and omnivorous habits. Conceivably the shift in activity pattern may have to do with an adaptive mechanism in relation to predators.

THE MUD MINNOW  
(*Umbra limi*)

Records on five adult mud minnows, 4 to 5 inches long, taken the last of July and first of August, 1929, at the Stone Laboratory, covered a period of 12 days,  $2\frac{1}{2}$  hours. The aquarium and other experimental conditions were the same as those used for the young carp. All of these fish were extremely sluggish during the day, lying by the hour without swimming the length of the aquarium. At night, however, a period of activity ensued which, while not intense, was well delimited from the rest of the day.

During the months of October and December ichthyograms were taken of mud minnows which had been carried from Put-in-Bay to the laboratory of Biology at Wooster. The experimental tanks were approximately 24 by 7 inches, of stone and with a sand bottom, in a basement room with temperature ranging from 17° C. to 24° C. Activity of three fishes covering 12 days and 20 hours was recorded. It was rather surprising that the fish were much more active than during the summer. Furthermore the pattern had entirely changed. There was no period of increased activity at night. If anything, the fish were more active by day.

During the course of a six-day experiment on mud minnow No. 6 a cover was placed on the experimental tank in such a way that the end of the tank farthest from the apparatus was darkened as contrasted to the other end. The graphs show clearly the gradual development of an activity pattern in response to this situation. On the first three days the fish was to be found about as frequently during the day hours in one part of the aquarium as in another. On the fourth day during the morning a rather marked "preference" for the dark end of the tank developed. Still there were frequent trips to the lighter end. During the afternoon the fish went only twice to the lighter end. But at 6:00 P. M. it started swimming the length of the aquarium and made many such excursions during the night. The next morning the fish remained at the dark end of the tank. The cover of the tank was carefully removed at 11:15 A. M. and replaced at 12:30 P. M. During this interval the fish swam the length of the tank 24 times. At 2:30 P. M. the cover was again removed and replaced at 3:45 P. M. In this interval there were 26 excursions the length of the tank. At 5:30 P. M. the fish again started swimming the length of the aquarium and continued intermittently until 7:30 A. M. Experiments on this day with removal of the tank cover were followed by similar results. Again at 5:30 P. M., about dusk, excursions the length of the tank began.

It is quite clear that the position of the fish in the aquarium was regulated by response to light stimuli. In fact one could determine quite well from these records the hours of dusk and dawn. The response of the fish when the cover was removed was in no case immediate, but occurred about two minutes after the change in light took place. During the course of experiments on mud minnows records were taken on three

specimens over periods sufficiently long to indicate that there is a change in total activity from day to day with the suggestion of a cycle of several days duration.

#### THE GOLDFISH

(*Carassius auratus*)

In the winter of 1932 activity records were secured for 5 goldfish varying in length from 4 to 6 inches. The experimental tanks in the Wooster laboratory were similar to those used for the mud minnow, but were not covered. Temperatures ranged from  $17\frac{1}{2}^{\circ}$  C. to  $21^{\circ}$  C. Water flowed slowly through the tanks during the experiments. The fish were fed once a day on dried entomostraca.

Between January 10th and February 17th a total of 39 days of activity records were taken of these 5 fish. Approximately 10 days' records were taken under continuous light, a 75-watt light bulb suspended 3 feet above the center of the experimental tank. The remainder of the records were taken under the natural light which entered the basement room.

Under natural light conditions the goldfish were, in general, more active during the day, and particularly during the hours from 1:00 A. M. to 6:30 A. M. there was a tendency to slow down. These findings are in accord with those of Szymanski (1914) for the goldfish. Continuous light of the intensity used served to reduce the total activity, and at the same time to distribute it more evenly over the 24 hours. However, the diurnal rhythm was not entirely eliminated after several days exposure to continuous light.

All of the ichthyograms on fishes No. 4 and 5 were taken under natural light conditions and they indicate that activity rises slowly to a peak over a period of several days' duration and then drops off rather suddenly to rise again. This rhythm in No. 4 consisted of a cycle approximately 6 days long and in No. 5 of a cycle 2 to 3 days long. It is clear from our records that activity in individuals cannot be properly compared and contrasted by taking records for one or two days only. Some of the records on Nos. 4 and 5 were taken simultaneously in parallel compartments under identical conditions and for a certain day one fish was more active and for another day the other was the more active. These long cycles of activity in fish are of particular interest in comparison with the findings of Richter (1927) on such cycles in rats.

Our experiments showed individuals differing from one another in total activity over periods covering the entire cycle, so that one goldfish might be described as sluggish and another as hyperactive. More striking than the variation in total activity was the tendency for certain individuals to develop an individual activity pattern. Three of the goldfish, Nos. 1, 3, and 5, swam during the night hours mostly at the end of the tank farthest from the recording apparatus. During the day their preference if any was for the other end of the tank. Fishes 2 and 4 showed no tendency to develop this particular activity pattern. The pattern referred to could be broken up

TABLE II  
ACTIVITY CYCLES IN THE GOLDFISH

Fish No.	DATES OF		Duration of Cycle in Days
	Minimum Act.	Maximum Act.	
1	Dec. 10.....	Dec. 14.....	4
1	Dec. 14.....	Dec. 19.....	5
2	Jan. 16.....	Jan. 21.....	5
2	Jan. 21.....	Jan. 26.....	5
2	Jan. 26.....	Jan. 31.....	5
2	Jan. 31.....	Feb. 6.....	6
2	Feb. 6.....	Feb. 11.....	5
2	Feb. 11.....	Feb. 16.....	5
2	Feb. 16.....	Feb. 22.....	6
2	Feb. 22.....	Feb. 28.....	6
2	Feb. 28.....	Mar. 6.....	7
2	Mar. 6.....	Mar. 10.....	4
2	Mar. 10.....	Mar. 16.....	6
3	Mar. 16.....	Mar. 20.....	4
3	Mar. 20.....	Mar. 25.....	5
3	Mar. 25.....	Mar. 29.....	4
3	Mar. 29.....	April 2.....	4

immediately by the use of continuous light. However, it is not understood why at dusk the far end of the tank was sought and occupied until dawn or a little after.

From December 11th, 1935, to March 23rd, 1936, Mr. William Kieffer and the author secured an extensive series of graphs of the activity of 7 goldfish totaling 4,326 hours recorded. These experiments were run in the same tank as those described above with the temperature at about 20° C. and seldom fluctuating more than two degrees from this. These fish were fed regularly once a day about .1 gram of imported oriental fish food. All grew during the course of the experiment and

there was no mortality except one accidental death due to a fish jumping out of the aquarium. This series of experiments corroborated the findings recorded above on individual variability in total activity and pattern of activity. All showed long cycles of activity lasting from 4 to 7 days. Some of the data on this point are given in Table II. Four of the seven fish showed a marked tendency to turn much more frequently to the right than to the left. Most of the fish generally came to rest with the tail under the eyelet of the recording apparatus. One rested with the head under the eyelet.

The data secured by Kieffer show a very definite relationship of activity to feeding. When the fish are well and regularly fed there is an intense activity period lasting from one to three hours after the food is placed in the tank. The fish actually consume the food in 15 minutes or less and the intense activity far exceeds this time. By covering the tank by day and lighting artificially at night and feeding at night the regular diurnal rhythm could be obliterated.

#### RECORDS ON OTHER SPECIES

Fragmentary records of a day or so were taken on the yellow perch, *Perca flavescens*, showing long periods of 15 minutes to an hour in which the fish remained motionless, interspersed with short excursions seldom more than the length of the tank and back, and often shorter. The record, totally different from that of carp, goldfish or the Centrarchidae, is probably typical of a darter, lying quietly on the bottom of stream or lake for a long time.

Records of the bull-head, *Ameiurus melas*, and the channel-cat, *Ictalurus* sp., also fragmentary, showed the former to be somewhat more active than the latter. Neither showed much difference between day and night swimming, certainly no clearly defined rhythm as in sunfish and young carp.

#### SUMMARY AND CONCLUSIONS

The author presents these data as a preliminary study of behavior patterns in fresh-water fishes. He is fully aware that the experiments are not complete, and that many factors could be more carefully controlled and studied. However, the data here presented indicate some of the problems which might further be investigated and the possibilities of the ichthyometer as a tool for their study.

Obviously it is impossible to have published all of the graphic records secured, which total over 200 yards of material and represent more than 100 swimming miles. It seems unwise even to include adequate samples of all the points covered. Rather we have chosen to publish one plate to illustrate the nature of these ichthyograms.

The findings reported here may be summarized as follows:

1. By the use of the ichthyometer it is possible to take continuous quantitative records of the total activity of various species of fish over long periods of time and under a variety of conditions planned by the investigator.

2. Fish show either a fairly continuous pattern of activity over a 24-hour period or a monophasic one conditioned apparently by reaction to light. There is no indication of any well defined short-period rhythm such as reported for rats and birds.

3. Certain fish are active by day and quiet at night; other species show the reverse pattern.

4. There appear to be marked seasonal and age differences in the activity pattern of certain species.

5. Individuals of a species show marked variations both in the intensity of their activity and in its pattern, so that it may be stated that the individual pattern is superimposed on the racial one.

6. Long cycles of some days duration leading gradually to a peak of activity followed by a sudden drop to a minimum and subsequent rise have been shown to occur in goldfish and seem to be present in the mud minnow. Records of other species studied do not cover periods long enough to furnish data on this point.

7. Light intensity and time of feeding definitely affect activity. The response to both of these stimuli outlasts by an appreciable length of time the application of the stimulus. In the mud minnow it has been shown that the application of certain light stimuli is followed by a latent period of a minute or more before the swimming reaction occurs.

#### ACKNOWLEDGMENTS

The writer wishes to express his grateful appreciation to the following persons:

1. Dr. W. M. Barrows, in whose laboratory the initial experiments were performed.

2. Dr. R. C. Osburn, for the use of facilities at the Stone Laboratory at Put-in-Bay.

3. Dr. R. V. Bangham, for co-operation in the work carried on at the Wooster Laboratory of Biology.

4. Miss Laura Blon and Mr. William Kieffer, undergraduates at Wooster, who secured many of the graphic records on goldfish.

#### BIBLIOGRAPHY

- Johnson, M. S. 1926. Activity and distribution of certain wild mice in relation to biotic communities. *Jour. Mammal.* 7: 245-277.
- Polimanti, O. 1911. Activité et repos chez les animaux marins. *Bull. de l'Inst. Gen. Psychol.* 11: 125-163.
- Richter, C. P. 1927. Animal behavior and internal drives. *Quart. Rev. Biol.* 2: 307-343.
- Spencer, W. P. 1929. An ichthyometer. *Science* 70: 557-558.
1929. Day and night periodicity in the activity of four species of fresh-water fishes. *Anat. Rec.* 44: 197.
- Szymanski, J. S. 1914. Eine Methode zur Untersuchung der Ruheund Aktivitätsperioden bei Tieren. *Arch. ges. Physiol.* 153: 343-385.
1919. Aktivität und Ruhe bei Tieren und Menschen. *Zeitschr. f. allg. Physiol.* 18: 105-162.
- Welsh, J. H. 1938. Diurnal rhythms. *Quart. Rev. Biol.* 13: 123-139.

---

#### Modern Inorganic Chemistry

After searching long and arduously for a book suitable as a text in a course in advanced inorganic chemistry, it is pleasing to find one which serves that need admirably. The authors depart entirely from the practice, too long followed in this field, of presenting a dictionary or encyclopedia of chemical compounds, their properties, preparation, and uses. Instead the authors believe that "it is more illuminating to deal with related compounds and special topics, which provide, as it were, a cross-section of the subject. To take a case in point, it is more instructive to treat the hydrides as a related group than in isolation, as compounds of the parent elements." The wisdom of this view is amply demonstrated.

To anyone, student, teacher, or research worker, desiring a thoroughly up-to-date treatment of the theories of inorganic chemistry together with a resumé of recent advances in the knowledge of the elements and their inorganic compounds, Emeleus and Anderson may be recommended without hesitation. The amount of information assembled here is astonishing. While it is hardly possible to mention all topics discussed, some idea of the breadth of the work can be seen from the chapter titles: atomic structure and the periodic system, atomic weights and isotopes, structure of molecules, co-ordination compounds and inorganic stereochemistry, poly-acids and silicates, hydrogen and the hydrides, free radicals of short life, non-metallic oxides, recent chemistry of the non-metals and of the metals, peroxides and per-acids, metallic carbonyls and nitrosyls, intermetallic and interstitial compounds, reactions in liquid ammonia and liquid sulfur dioxide, and radioactivity and atomic disintegration.

No work of this kind can be "easy" reading in its entirety, but this book is remarkably so. Typographical and factual errors are few.—*W. C. Fernelius.*

**Modern Aspects of Inorganic Chemistry**, by H. J. Emeleus and J. S. Anderson. xi+536 pp. New York, D. Von Nostrand Co., 1938. \$9.00.

# THE NUMERICAL STATUS OF SOME MAMMALS THROUGHOUT HISTORIC TIME IN THE VICINITY OF BUCKEYE LAKE, OHIO<sup>1</sup>

MILTON B. TRAUTMAN

Museum of Zoology, University of Michigan

While examining literature for references to the flora, avifauna and general conditions throughout historic time<sup>2</sup> in the vicinity of Buckeye Lake, Ohio, for my report upon the birds of that area, I collected data on the numerical status of several mammal species. Between the years 1922 and 1935 I interviewed many of the old residents of the Buckeye Lake area and obtained their impressions of the time of disappearance or numerical changes in abundance of several mammal species during the period from 1860 to 1935. Between 1922 and 1933 I also made personal observations upon several mammal species.

Before proceeding with the mammal records it is necessary to give a brief history of the changes which have taken place in the vicinity of the present Buckeye Lake. Gist (1893:42), Smith (1870: 21) and others have indicated that before 1800 the area now covered by the waters of Buckeye Lake was a "Great Swamp." This swamp contained one or more small glacial lakes which were surrounded by cranberry-sphagnum-red maple bogs, considerable brush, and swamp forests of the elm-ash-soft maple type. Extending immediately northwest of the "Great Swamp" was another which later became known as "Bloody Run Swamp." This latter swamp extended to the present site of Kirkersville and contained a mixture of cranberry-sphagnum-red maple-poison sumac bog-swamps, alder-red ozier brush communities, and swamp forests of the elm-ash-soft maple-pin oak type. The adjacent country northeast, east and south of the present Buckeye Lake was principally rolling upland, with glaciated hills less than one hundred and fifty feet in height. The better drained portions of the uplands contained tall forests which seemingly were principally of the oak-hickory-hard maple-chestnut type (Smith, 1870: 20 and Schaff 1905:

---

<sup>1</sup>For information concerning the flora, avifauna and general conditions in the Buckeye Lake area during historic time see my forthcoming report on "The Birds of Buckeye Lake, Ohio," *Misc. Publ., Mus. Zool., Univ. Mich.*

<sup>2</sup>For the region under treatment historic time extends from January, 1751, to the present.



82-89). The less well-drained lower slopes and intervalles contained a beech-maple forest type. The writings of Smith (1870: 21 and 168), Hill (1881: 199) and others indicate that the Great and Bloody Run swamps and adjacent uplands were a favored hunting ground of the Indians before 1800, and that two important Indian trails passed beside this hunting ground.

The Great and Bloody Run swamps and adjacent uplands, hereafter referred to as "the Buckeye Lake area" or "the area," was little affected by the white man until after 1800. The settling of the area, removal of the forest, and cultivating of land (particularly uplands) became pronounced shortly after 1800, and by 1820 several towns, such as Newark (1802), Granville (1806), Thornville (1815), Lancaster (1800), and Somerset (1807), had been established. Drastic changes in the Great Swamp began in 1826 with the building of the canal and the "Old Reservoir." The reservoir was filled with water in 1830, thereby eliminating most of the Great Swamp. In 1836 construction was begun on the "New Reservoir," immediately west of the first one, and it was filled with water a few years later.<sup>3</sup> The building of the National Road across the northern edge of the area was started in 1825 and completed a few years later. The canal, reservoirs, and National Road greatly hastened the settling of the country, the removal of the forests, and the general modification of the topography. By 1840 the forests of the uplands had been cut over, the Great Swamp was water-covered, and only the Bloody Run Swamp remained in a more or less primitive state.

Changes were almost as drastic during the period from 1850 to 1900 as in the preceding fifty years. In 1855 the third major method of transportation, the railroads, was added. All three agencies of transportation greatly increased the accessibility of the area, opened markets for farm produce, and in general caused an ever increasing amount of forest and brush removal. During this period attempts were made at draining portions of the hitherto inaccessible Bloody Run Swamp.

The operation of interurban electric lines beginning in 1901 considerably increased the number of persons annually visiting the area, and also augmented the amount of hunting. By 1914 the automobile had become a profound influence in modifying

---

<sup>3</sup>The reservoirs were first known as the Licking Summit Reservoirs, later as Licking Reservoir; in 1894 an Act of the Legislature changed the name to Buckeye Lake.

the roads and all other features of the area, besides greatly increasing the number of visitors. Between 1900 and 1930 the Bloody Run Swamp, the last partially unmodified section, was almost entirely drained, de-brushed and deforested. The final result of deforestation, de-brushing, draining, flooding and cultivating, and the making accessible of the land to large numbers of people has resulted in (1) the entire elimination of the "Great Swamp" and the creation of the present Buckeye Lake, (2) removal of all forests except secondary remnants, and (3) draining and cultivation of the Bloody Run Swamp until today its once distinctive flora and fauna is essentially that of the immediately adjoining region.

#### CHANGES IN NUMERICAL STATUS OF SOME MAMMALS

American Elk (*Cervus canadensis canadensis*) was recorded as late as 1755 by Smith (1870: 20-21) and were perhaps present until a few years later.

Several Bison (*Bison bison pennsylvanicus*) were killed in this area or the immediate vicinity in 1755 (Smith, 1870: 21). According to Smith the species was quite numerous in eastern Ohio between 1755 and 1759, and was much hunted.

American Beaver (*Castor canadensis*) was probably present in 1755. While traveling with the Indians in the general vicinity of Buckeye Lake, Smith (1870) frequently observed the trapping and catching of beaver. Schaff (1905: 113-114) mentioned the existence of a beaver dam "about three feet high and seventy-five feet long," and beaver meadow, which he saw a few miles east of Kirkersville when he was a boy (1840-1858). Schaff (104) had "no doubt" that Bloody Run Swamp was enlarged by beavers damming Bloody Run, but gave no evidence to support this theory. He was "inclined to think" that beaver "disappeared with the Indians or perhaps sooner." The early extinction of the beaver, bison, and elk may not have been entirely the work of the white man, since some of the Indians of eastern Ohio had guns and steel traps during the early years of the eighteenth century. Smith (1870: 24 and 60) repeatedly mentioned that the Indians used guns and steel traps between 1755 and 1759. Schaff (1905: 116-117) suggested that "as soon as fire arms were substituted for bows and arrows, and steel traps for simple wooden devices and dead falls, the destruction of game must have gone on rapidly." Possibly over-hunting by Indians, or Indians and white men, caused the elk, bison and

beaver to disappear in the area before the pioneer farmer and his destruction of primeval conditions became a factor.

Panthers (*Felis concolor couguar*) are frequently referred to in the literature but generally it is not clear whether the name "panther" refers to this species or the bobcat. *Felis concolor couguar* was in the general vicinity of the area in 1805 and was probably in the Great and Bloody Run swamps for several years thereafter. Smucker (1876: 45) related that in the autumn of 1805 Jacob Wilson, who was then living within a mile of Newark, treed with his dogs and then killed a "huge panther" that had previously raided his pig pen and carried away a pig. Brayton (1882: 8) considered this animal to have been *Felis concolor*.

Bobcats (*Lynx rufus rufus*) are indicated by the literature references as probably having been rather numerous, and they presumably remained in the large wooded and swampy areas after the panther had been extirpated. However, no reliable data of the actual capture of the bobcat in the area has been found. Many of the older residents claim that their fathers killed bobcats in Bloody Run Swamp as late as 1860. Schaff (1905) did not mention this species as occurring between 1840 and 1858.

American Otter (*Lutra canadensis canadensis*) was mentioned by Hill (1881: 176) as occurring in "considerable numbers" in the swamps of Licking County in early historic times. Kirtland (1838: 176) stated that it was common in Ohio as late as 1838. Schaff (1905: 97) related that between 1840 and 1858 "Otter tracks were often seen in the snow as they crossed to and from the Reservoir [Buckeye Lake] to the creek [Bloody Run]."

Black Bears (*Euarctos americanus americanus*) are mentioned in many undated references. They were apparently present until at least 1825 and possibly as late as 1840 (Hill, 1881: 176; and Graham, 1883, Pt. 5: 13). Schaff (1905: 91) claimed that bear, as well as beaver, buffalo, elk and deer had disappeared before his time (1840-1858). Graham (1883, Pt. 5: 314) stated that "Bears were very numerous about the original lakes and swamps. Indians and whites alike made it a business to hunt and kill them. In very early time, bears from other parts of the county were chased into the swamps and lowlands, where the Reservoir [Buckeye Lake] now is. They could not always be followed up successfully, and sometimes their capture had to be given up." Like the Indians before them, the early pioneers

considered the bear an important article of food. With the introduction of live stock and cultivation of crops the bear and other once important food animals became "vermin." Consequently methods were employed to decrease their numbers or extirpate them from the area. One method of reducing their numbers was through community or circular hunts such as were described by the Rev. Timothy Howe (Schaff, 1905:148-152; and Smucker, 1876:49-52) and Samuel Park (Hill, 1881:604). One of these hunts, which took place between 1823 and 1825, was most graphically described by Howe. He related that a tract of land which embraced "Gibbon's Deadening"<sup>4</sup> in Harrison Township, Licking County, was chosen for a hunt. Shortly before the actual hunt was to take place the Surveyor of Licking County surveyed the area to be hunted and outlined it by blazing trees. On the day of the hunt, most of the people of the community for miles around came to the deadening, and after all had assembled, the members of the party were placed in a line which completely encircled the area to be hunted. Some of the hunters were on horseback while the remainder were afoot, and at a signal, the entire assemblage began to march toward a given center, driving the game before them. When the circle became sufficiently small, the better marksmen were sent into the circle to shoot whatever game it might contain. At this particular hunt the bag consisted of "one large black bear, three wolves, forty-nine deer, sixty or seventy turkeys, and one owl" (Schaff, 1905:151).

Timber Wolves (*Canis lupus*) were frequently mentioned, and were indicated as present in 1823 (Schaff, 1905:151) and probably for several years thereafter. Hill (1881:176) wrote that a bounty of as much as four dollars was paid for the scalp of a large wolf, according to the record of the Licking County Commissioners. Graham (1883:201) states that in 1815 a den of cub wolves was captured in Hopewell Township, Perry County.

White-tailed Deer (*Odocoileus virginianus*) were unquestionably very numerous until at least 1825, and are frequently mentioned in the literature (Hill, 1881:176; Graham, 1883,

---

<sup>4</sup>A "deadening" was a section of forest in which the trees had been girdled, causing them to die. After the trees had been dead for several years, and many of their limbs had fallen off, the dead timber was chopped down or burned and the land cleared of logs and brush, preparatory to farming. In the interim between the girdling of trees and clearing of land, a brush-thicket habitat invaded the area, providing excellent cover for the larger mammals.

Pt. 3: 15 and Pt. 5: 314). Schaff (1905: 151) recorded the killing of forty-nine deer in the "vermin drive" related above. He also stated (p. 91) that deer had disappeared from Bloody Run Swamp before his time (1840-1858). However, the older residents who were interviewed claimed that deer were present in Bloody Run Swamp until about 1855.

Raccoons (*Procyon lotor lotor*) were apparently very numerous throughout all of central Ohio, for they were mentioned as frequently as the deer. Smith (1870) repeatedly touched on the abundance of raccoons in eastern Ohio between 1755 and 1759, and indicated that the Indians trapped them in large numbers. Schaff (1905: 97) stated that "raccoons and opossums were numerous" during the 1840 to 1858 period. The old market hunters and sportsmen claim that the raccoon was more diurnal in early historic times than it is today. As late as 1885, according to these men, one to twelve raccoons could be killed per day during late summer by walking along the banks of streams and shooting them as they searched for crayfish and other food. The men also stated that there has been a rather steady decrease in the numbers of raccoons from 1885 to the present day, coincidentally with the decrease in size and amount of forest remnants, and a reduction in the number of large den trees. This decrease in raccoon numbers has occurred in spite of ever increasing restrictions in hunting.

The Gray Fox (*Urocyon cinereoargenteus cinereoargenteus*), a woodland inhabitant and seemingly a rather stupid animal, was apparently very common in early historic time. Its abundance and the absence or extreme scarcity of the red fox in those times is frequently mentioned in early Ohio literature. Kirtland (1838: 176) stated that the gray fox was "very abundant" at the coming of the white man, and that it disappeared "before the advancement of civilization." Of the red fox he wrote that it "was unknown in this region of country [Ohio] until the introduction of the white population," but that by 1838 it had become "a common and troublesome inhabitant." The older residents give the time of final extermination of the gray fox in the Buckeye Lake area as between 1855 and 1875. Writing of his experiences in Bloody Run Swamp between 1840 and 1858, Schaff (1905: 97) states that by that time gray foxes had disappeared.

The Red Fox (*Vulpes fulva fulva*) was apparently very rare in early historic time. In relating his experiences while hunting

the red fox (on horseback and with packs of hounds) in the area and vicinity, Schaff (1905: 97) gave the impression that this species was numerous between 1840 and 1858. William Harlow, Stephen Holtzberry, and other old residents have informed me that this inhabitant of the field-brush-remnant forest community was very numerous during the period from 1860 to 1900 but that it has since decreased in numbers. A few considered the decrease as great; others thought it was rather slight.

Gray Squirrels (*Sciurus carolinensis*) were not definitely recorded in the area before 1820, but it is assumed that this forest-inhabiting species was present from 1751 to 1820 and possibly was as abundant then as it was between 1823 and 1875. Schaff (1905: 97) mentioned that black squirrels (presumably a phase of the gray squirrel), gray squirrels, and flying squirrels (*Glaucomys volans volans*) were "in every wood" during his boyhood (1840-1858). By 1807 (Jones, 1898: 168) this squirrel had become such a nuisance to the farmer that the Ohio Legislature passed an Act requiring every person within the state, subject to payment of tax, to furnish a specified number of squirrel scalps within a given period (tails were usually substituted for scalps). If the evidence of kill was not produced the penalty was the same as that for a delinquent tax payer. Despite this persecution the squirrels "ocasionally" became exceedingly numerous.

One method of reducing the number of gray squirrels was by competitive hunts. Such hunts were frequently comprised of two companies or sides and the company killing the greatest number of animals usually won a prize. Hill (1881: 605) mentioned such a hunt which occurred in 1822, when for a day and a half, one group hunted in Granville Township, Licking County, and the other in Union Township (in the Buckeye Lake area) of the same county. In this hunt only rifles were used and the result was the killing of more than 3,800 squirrels (a little over nineteen hundred on a side). This number seems very large, but does not compare with the incredible number killed in the famous Franklin County squirrel hunt of August 10, 1822. It is claimed that in this hunt, which lasted a day, about two hundred men killed 19,650 squirrels (Jones, 1898: 172; and Hill, 1881: 605). Despite the persistent persecution and hunting of gray squirrels their numbers remained very large in the Buckeye Lake area, according to the old residents, until about

1880. After 1880 the forest remnants became too small and isolated to support the former large numbers and a decided decrease began. By 1910 the status of this squirrel had changed from that of a nuisance to that of a sporting game mammal. Despite ever increasing restrictions on its capture, the species disappeared from the area before 1920. The late game protector Earl McPeak told me that the last gray squirrel he saw, which had been killed in the area, was taken in the fall hunting season of 1918. During my investigations in the area between 1922 and 1933 I saw none and heard of no one who had seen any. Despite much persecution this animal remained immensely abundant as long as the environmental factors were sufficient. It became extirpated from the area when the amount of available habitat was at its lowest ebb, although the animal itself was receiving the greatest amount of legal protection from hunting and persecution that it had at any period of historic time.

Fox Squirrels (*Sciurus niger rufiventer*) were originally rare or absent over large areas of Ohio. The absence of references to this squirrel in early Ohio literature forces one to this conclusion. Schaff (1905) gave no indication of the presence of the animal between 1840 and 1858, although he frequently mentioned other squirrel species. The older residents of the area do not remember this conspicuous species between 1860 and 1870. Some claimed that it appeared in the area about 1875 and that it showed a rather consistent increase in numbers until 1900 to 1910. After 1915 a slight decrease was noted. These statements seem plausible when it is remembered that the fox squirrel is chiefly an inhabitant of grove-like forests (often an oak-hickory association) of rather small extent, surrounded by brush or cleared land. Such conditions were unusual before 1825, increased greatly in amount between 1830 and 1900, and began to decrease after 1900. During my investigations from 1922 to 1933 the fox squirrel population of the Buckeye Lake area showed a decrease, which was coincident with the continued removal of the remnant forests and the over-grazing of the woodlands. In this period hunting was judged to be of less importance as a detrimental agent than were other factors.

Cottontails (*Sylvilagus floridanus mearnsii*) were apparently of little importance to the early pioneers, for the early records of rabbits in the area are few and vague. Curiously, Schaff (1905) did not mention the rabbit in his recollections of the area

between 1840 and 1858. Despite the lack of definite records it seems safe to assume that the species was present before 1800, at least about forest edges, in brush lands, and in forest openings. Obviously this inhabitant of open, woodland remnants, brushlands and fields must have greatly increased in abundance with the augmentation of favorable conditions. The old residents have informed me that despite much trapping, hunting and other persecution the cottontail was very numerous during the period from 1860 to 1895, especially in the occasional or cyclic "rabbit years;" and that by 1910 the cleaning up or grazing of woodlands, brushlands and fields, and draining of swamps, had resulted in a decrease in numbers. This decimation has continued, in spite of increased protection. I noted a gradual decrease between 1922 and 1933. In this period the rabbit became rather uncommon on the most over-grazed and highly cultivated farms, and especially in the uplands where the fertility of the soil was low.

Muskrat (*Ondatra zibethica zibethica*) was surely present about the original glacial lakes and swamps of the area, although there is a lack of definite early records. Writing of conditions between 1840 and 1858, Schaff (1905: 97) mentioned that "along Bloody Run and Licking [South Fork of Licking River] muskrats abounded." By 1850, after completion of the reservoirs and the subsequent establishment of large cattail marshes, the species had probably become very numerous. According to the old residents this mammal was abundant during the period from 1860 to 1910, and the trapping of the animal for its fur was the principal occupation of several men during the latter half of the period. The residents state that muskrats have become reduced in numbers in recent years coincidentally with the decrease in area of marshland, and in spite of increased hunting restrictions. Between 1922 and 1933 I observed the draining of several swamps and marshes, by which the amount of available habitat in the area was materially reduced and the number of muskrats was consequently decreased.

Nothing has been found concerning the abundance of mice in the area in early historic time, although mouse concentrations have been mentioned in early literature for other sections of Ohio. The Field Mouse (*Microtus pennsylvanicus pennsylvanicus*) and the Northern Deer Mouse (*Peromyscus leucopus noveboracensis*) are no doubt the species principally referred to. During several years in the period from 1922 to 1933 I noted



marked concentrations of mice, usually in isolated areas of 50 acres or less. The farmers claimed that they first heard of or began seeing these concentrations about 1915, that they were increasing in size and numbers, and that they were not of yearly occurrence.

#### GENERAL CONCLUSIONS

Several conclusions can be gleaned from these mammal records. The elk, bison, and beaver became rare or were extirpated from the area coincidentally with the coming of the white man. The use of guns and steel traps by the Indians seems to have been a determining factor in the early elimination of these species.

The black bear, white-tailed deer, timber wolf, otter, panther, and bobcat were present between 1751 and 1820. They were extirpated from the area between 1820 and 1850, contemporaneously with the flooding of the "Great Swamp," the beginning of the destruction of Bloody Run Swamp, and the removal of the upland forests.

Such medium-sized mammals as the raccoon, gray fox, and gray squirrel which were inhabitants of the forest or were tolerant of forest conditions, are at present greatly reduced in numbers or have been extirpated.

Mammals that are not chiefly forest inhabitants, such as the fox squirrel and rabbit, are assumed not to have been numerous before 1825; to have increased greatly with a moderate deforestation and the establishment of much brushland and fields; to have reached a climax in abundance during the period from 1850 to 1900 when such conditions were most prevalent; and to have decreased in numbers with the advent of over-grazing and modern "cleaning up" farming.

This study of the literature and unpublished data suggests that the large, wide-ranging, chiefly forest inhabiting species were first extirpated; that the forest-brush inhabiting, moderate-sized species were next extirpated; and that species of the open woodlands, brush and fields occur at present. We therefore postulate that the modifications in topography and flora made by the white man throughout historic time have been reflected in the changing numerical status of the mammalian species. With few possible exceptions the numerical increase or decrease of a species closely followed the increase or decrease

in the amount of its habitat,<sup>5</sup> except in so far as the species was unduly hunted or persecuted. If the species was not given sufficient protection it became exterminated before its environment was destroyed.

<sup>5</sup>Species having cyclic abundance probably do not show the effects of changing environment as rapidly as do non-cyclic species, but the general trend is the same.

#### LITERATURE CITED

- Brayton, A. W.**  
1882. Report on the mammalia of Ohio. Geol. Surv. of Ohio. 4: 1-185.
- Gist, Christopher**  
1893. Christopher Gist's journals with historical, geographical and ethnological notes and biographies of his contemporaries by W. M. Darlington. Pittsburgh: J. R. Welden and Co., 1-296, 8 maps.
- Graham, A. A. (compiler)**  
1883. History of Fairfield and Perry Counties, Ohio. Chicago: W. H. Beers and Co., Pt. 1, 1-92; Pt. 2, 93-210; Pt. 3, 1-198; Pt. 4, 199-392; Pt. 5, 393-596, 2 maps.
- Hill, Jr., N. N. (compiler)**  
1881. History of Licking County, Ohio. Newark, Ohio: A. A. Graham and Co., 1-822, also numerous figures.
- Jones, N. E.**  
1898. The squirrel hunters of Ohio. Cincinnati: Robert Clarke and Co., i-viii, 1-363.
- Kirtland, J. P.**  
1838. Report on the zoology of Ohio. Second Ann. Rep. of the Geol. Surv. of the State of Ohio: 157-177.
- Schaff, Norris**  
1905. Etna and Kirkersville. Cambridge: Riverside Press, 1-157, 1 map.
- Smith, James**  
1870. An account of the remarkable occurrences in the life and travels of Col. James Smith, during his captivity with the Indians, in the years 1755, '56, '57, '58, and '59. With an appendix of illustrative notes by Wm. M. Darlington of Pittsburgh. Cincinnati: Robert Clarke and Co., i-xii, 1-190 (Ohio Valley Historical Series No. 5).
- Smucker, Isaac**  
1876. Centennial history of Licking County, Ohio. Newark, Ohio: Clark and Underwood, 1-80.

---

#### Newton

It is not infrequent that the private lives of many of the eminent scientists of the present and the past escape us entirely although their works occupy a prominent place in our daily existence. *Isaac Newton*, a biography of the author of the theory of gravitation, written by J. W. N. Sullivan and completed just briefly before his death, gives to the reader an interesting glimpse into the life of the great scientist. It reveals in an interesting manner how, in addition to being an indisputable scientific genius, Newton also was a most outstanding and noteworthy character in his private life. This sketch is well worth devoting a few hours to and can be recommended to the reader interested in the history of science.

—H. H. Nielsen.

*Isaac Newton*, by J. W. N. Sullivan. New York, The Macmillan Co., 1938.

REPORTS ON THE FLORA OF OHIO. I  
NOTES ON THE OHIO VIOLETS WITH ADDITIONS  
TO THE STATE FLORA\*

FREDERICK O. GROVER,  
Oberlin College

A recent study of the violets in the Oberlin College Herbarium disclosed specimens of a number of species, varieties and hybrids from Ohio, which extend the previously known ranges in the state, have not been reported from the state, or have not hitherto been described. In this report the species already listed from the state are prefixed by the serial number used by Professor Schaffner in his "Revised Catalog of Ohio Vascular Plants," 1932, and in his later additions in the OHIO JOURNAL OF SCIENCE. Varieties or forms of these species, newly reported, have the serial number with the letter a, b, or c suffixed. Many of the plants are authenticated by Dr. Ezra Brainerd. In each such case, the county from which the specimen came is marked with an asterisk (\*).

963. *Viola canadensis* L.

Professor Schaffner records this from "Eastern and Southern Ohio, northwestward to Huron, Fairfield, Highland and Hamilton." All of these counties except Huron lie South of an east-west line through Columbus. The Oberlin Herbarium extends the range northward into Muskingum,\* Licking,\* Lake,\* Cuyahoga,\* and Lorain.\* H. L. Jones, on the label of the Licking County specimen, collected in 1889, wrote, "Rare in Granville."

963b. *Viola canadensis* L. var. *pubens* Farwell.

This differs from the "essentially glabrous" plant by being "hirtellous throughout." It was described by O. A. Farwell from Washington, Mich., in Papers Mich. State Acad. Sci. II: 34 (1922) 1923. It has not been reported from Ohio, but should be looked for in the northwestern part of the state.

964. *Viola eriocarpa* Schw.—*V. scabriuscula* Schw. mss.

This was described by Schweinitz (1822) from plants growing abundantly in rich meadow bottoms near Salem, North Carolina. All of the plants had densely white-villose capsules. In 1837 Wm. Darlington, Fl. Cestrica, p. 147, described this species, "growing in moist woodlands, along the Brandywine" in Pennsylvania, as having "the

---

\*Papers from the Department of Botany, Oberlin College, No. 2.

capsule sometimes quite naked, often densely villose." Since then the capsule of *V. eriocarpa* has been described as "glabrous or tomentose," Britton, Man.; "woolly or sometimes glabrous," Britton and Brown, Ill. Fl.; "as in the preceding (*V. pubescens*)," Gray, Man. 7th ed.

Not until 1921 was the form with "ovaries and capsules glabrous" formally segregated under the name *V. eriocarpa* Schw. var. *leiocarpa* Fern. & Wieg., *Rhodora* 23: 275-276. 1921.

Professor Schaffner lists *V. eriocarpa* Schw. as of "general" distribution in Ohio, but he does not segregate var. *leiocarpa* Fern. & Wieg. from *V. eriocarpa* var. *typica*, with capsules densely villous.

964a. *Viola eriocarpa* Schw. var. *typica*.

A recent examination of *V. eriocarpa* in the State Herbarium yielded only nine specimens of this variety. These were from Ross, Warren, Delaware, Crawford, Richland, Huron, and Coshocton. To these Oberlin Herbarium adds Columbiana and Richland. There are no specimens in either herbarium from the western part of the state. The herbarium of Miss E. Lucy Braun adds Hamilton.

964b. *Viola eriocarpa* Schw. var. *leiocarpa* Fern. & Wieg.

This variety, on the contrary, has a state wide distribution. State Herbarium has it from 23 counties, and the Oberlin Herbarium from 6 other counties. Of these 29 counties, 17 are within the Appalachian plateau and the sandstone-shale region bordering it. Two counties, Franklin and Huron, lie in the transition zone, while 10 counties are in the limestone area of the western half of the State.

965. *Viola pubescens* Ait.—*V. pennsylvanica* Michx.

Aiton's description of this species (1789), Michaux's description of his *V. pennsylvanica* (1803), and Pursh's account of *V. pubescens* (1814) were all very brief, and were limited to habit and vegetative characters. They all described the plants as villose-pubescent, but none of them referred to the ovaries or capsules.

Thomas Nuttall, Gen. N. Am. Plts. I: 150, 1818, seems to have been the first to record the fact that some plants of *V. pubescens* have glabrous capsules, while others have capsules densely villous. He accepted the plant with smooth capsules as the type of Aiton's *V. pubescens*, and described the plant with villous capsules as a new variety under the name *V. pubescens*  $\beta$  *eriocarpon*. His differentiation of the two forms is as follows: "15. *V. pubescens*, *V. pennsylvanica* Mich. Leaves either very pubescent, or nearly smooth, subserrate; stipules ovate, mostly entire; fruit smooth," and " $\beta$  *eriocarpon*, Fruit densely villous; stipules smaller. In fruit this would be taken for a distinct species, as the character is constant; in any other respect it does not materially differ from *V. pubescens*; both these varieties are abundant near Philadelphia."

Schweinitz in his monograph of the North American species of *Viola*, Am. Jour. Sci. 5: 48-81, 1822, describes *V. pubescens* as "*capsulis glabris* (Nuttall; *etiam villosis*)," and concludes that "the var.  $\beta$  *eriocarpon* of Nuttall is not my *eriocarpa*, but really a variety of *pubescens*."

O. A. Farwell, Papers Mich. Acad. Sci. 2: 33, 1922, treats the plant with "woolly capsules" as a mere form under the name *V. pubescens* forma *eriocarpa* (Nutt.) Farwell.

Most botanists, however, have not followed Nuttall, Schweinitz and Farwell in segregating the plant with woolly capsules as a distinct variety or form. They have been content to describe *V. pubescens* as having "Capsules glabrous or woolly," Gray Man. 7th ed.; "capsules glabrous or tomentose," Britton Manual; "capsules glabrous or sometimes woolly," Britton and Brown, Ill. Fl. 2nd ed.; while Fr. Marie-Victorien in his Flore Laurentienne, p. 281, 1935, says, "fruit glabre." On the other hand, H. D. House, N. Y. State Mus. Bull. 243-244: 50, 1923, and Bull. 254: 510, 1924, has not accepted Nuttall's and Schweinitz' concept of Aiton's species. He takes Nuttall's variety *eriocarpa* as the type, and treats the plant with glabrous capsules as the variety, giving it the name var. *peckii* House. A letter to Mr. House, asking the basis for his treatment of the two forms, elicited the following reply: "Several years ago, just how many I cannot now say, the late Dr. E. L. Greene informed me that the type of *Viola pubescens* was the form so common in the east with woolly capsules. I do not know the source of his information and rather doubt if he ever saw the type, if it still exists." Fortunately, Mr. C. A. Weatherby of the Gray Herbarium was to be in England during the summer of 1937, and kindly offered to examine Aiton's plants, preserved at the British Museum, in the hope that the type specimen of *V. pubescens* might be among them. His report, July, 1937, was as follows: "The type specimen of *Viola pubescens* Aiton, preserved at the British Museum, has pubescent ovary and capsule." *V. pubescens* var. *eriocarpa* Nutt. is, therefore, a synonym of *V. pubescens* Ait., while *V. pubescens* Nutt., and Am. auth., is a synonym of *V. pubescens* Ait. var. *peckii* House.

Professor Schaffner in his Catalog of Ohio Vascular Plants has followed the common usage and treated *V. pubescens* as a unit. However, a recent examination of the specimens referred to *V. pubescens* in the State Herbarium shows that both forms occur in Ohio.

965a. *V. pubescens* Ait. var. *typica*.

This is represented from 12 counties, viz.: Ashtabula, Lake, Huron, Wood, Lucas, Medina, Stark, Hardin, Morrow, in the northern half of the state, and from only Fairfield, Warren, Jackson, in the southern half. To the northern section the Oberlin Herbarium adds Cuyahoga, Lorain, Erie, and Richland. Univ. of Michigan Herbarium adds Hancock.

965b. *V. pubescens* Ait. var. *peckii* House.

This is represented in the State Herbarium from only three counties, viz., Franklin, Coshocton, and Scioto. The Oberlin Herbarium adds Lorain. Miss E. Lucy Braun's Herbarium adds Hamilton.

966. *Viola hastata* Michx.

This has been reported from five counties in the northeastern and eastern part of the state. To these add Trumbull,\* Ashtabula,\* and Lorain.\* It is known in Lorain County only from one very limited

area, a few rods across, in "Bennett's Woods," Carlisle Twp., in the sandy alluvial soil of a very low rise in woods near Black River.

970. *Viola rostrata* Pursh.

Professor Schaffner says, "Rather general; but no specimens from the southwestern counties." Oberlin College Herbarium extends the range into Butler County, and has specimens from Erie, Lorain, Lake,\* Columbiana,\* Wayne,\* and Licking.\*

970a. *Viola rostrata* Pursh forma *trirostrata*, n. f., petalis lateralibus postice porrectibus vel rostratibus.

Lateral petals posteriorly lengthened or rostrate.—Occasional in open woods with the type, Russia and Amherst Townships, Lorain County.

This form was discovered in 1900 by Mr. Addison Gulick, a student in Oberlin College, in an open beech-maple grove on a terrace of Plum Creek, east of Oberlin. At that time he found five plants of *V. rostrata* with all of their flowers trirostrate, the spurs of the lateral petals being of approximately the same length as the spur of the nectary. With these were a number of plants having both trirostrate and normal flowers. One of the plants, transferred to Mr. Gulick's garden, continued to produce trirostrate flowers.

In 1904 Mr. Gulick made a more careful survey of the area and found seventeen plants with all of their flowers trirostrate, two with flowers incompletely trirostrate, that is with one lateral spur quite short, and five plants with both trirostrate and normal flowers. Since then plants with all or a part of their flowers trirostrate have been found in other sections of Lorain County.

971. *Viola rafinesquii* Greene.<sup>1</sup>

Add Preble.

971.1. *Viola arvensis* Murr.

Add Lorain, previously reported only from Geauga.

973. *Viola odorata* L.

Add Lorain. The purple-flowered form with very long freely rooting stolons is spontaneous under hedges in Oberlin. The form with petals white, or white streaked with purple, is rather common in Oberlin lawns.

976. *Viola pallens* (Banks) Brainerd.

Add Lorain\* and Trumbull.\* All of the counties listed by Schaffner, except Clinton and the extreme western part of Huron, are in the eastern sandstone and shale section of the state.

977. *Viola lanceolata* L.

It has been reported from only five scattered counties. Add Lorain.\*

<sup>1</sup>Change name to *Viola kitaibeliana* Roem. and Schultes, var. *rafinesquii* (Greene) Fernald, *Rhodora* 40: 443-446. Plate 526. 1938.

980. *Viola papilionacea* Pursh.

Dr. Brainerd in annotating the North American Violets in the Oberlin College Herbarium treated as true *V. papilionacea* only those specimens which were glabrous throughout. Those which were more or less pubescent he annotated "*V. papilionacea* toward *V. sororia* in subpubescence," thus treating them as probable hybrids or hybrid derivatives of the two species.

980a. *Viola papilionacea* Pursh forma *albiflora*, n. f. petalis omnino albidis, vel petalo infimo purpureo-striato.

Petals wholly white or with the lowest one streaked with purple.—Lorain, (Ob. Coll. Herb. 88410), Cuyahoga (Ob. Coll. Herb. 80002). This should be looked for elsewhere in the state.

981. *Viola sororia* Willd.

Prof. Schaffner lists eight counties, all but Wood and Lake being in the southern half of the state. To the northern group add Lorain,\* Erie, Richland.\*

982. *Viola hirsutula* Brainerd.

Add Licking\*. This Southern Wood Violet has been reported from only four counties, all in the central part of the state, on the edge of the Appalachian plateau.

989b. *Viola pedata* L. var. *lineariloba* DC. (*V. pedata* Curtis, *V. pedata* L. var. *concolor* Theo. Holm.).

This is in the Oberlin Herbarium from Lake\* and Lorain\* Counties, annotated by Dr. Brainerd "*Viola pedata* L. var. *concolor* Holm." The specimen of *V. pedata* in the State Herbarium collected by Miss Alice Griswold in open woods near Painesville, Lake County, May, 1884, is this variety. Mr. Floyd Bartley recently told the writer that he had found it in the Oak Openings of Lucas County, and in Lawrence and Scioto Counties. It is probably to be found wherever the species occurs.

—. *Viola incognita* Brainerd.

Dr. Brainerd has referred two plants from Ashtabula\* and Trumbull\* Counties to this species. It has not previously been reported from Ohio.

988. *Viola sagittata* Ait.987. *Viola fimbriatula* J. E. Smith (*V. ovata* Nutt.).986. *Viola emarginata* (Nutt.) Le Conte.

*Viola sagittata* var. *subsagittata* Farwell.

*Viola subsagittata* Greene.

So much confusion exists concerning these five forms that it seems necessary to discuss them together and in some detail.

988. *Viola sagittata* Ait.

This was described from plants sent to England in 1775 from "Pennsylvania," probably by John Bartram, who about 1730 established a Botanic Garden on the bank of the Schuylkill River just below Phila-

delphia. Thus the habitat of the plants on which the species was based was probably low, moist ground of the Atlantic Coastal plain.

Aiton described the leaves as "subpubescent." Nuttall (1818) described them as "nearly smooth, or sometimes slightly pubescent on the upper side."

Later botanists have very generally considered typical *V. sagittata* to be the glabrous or nearly glabrous plant with mature leaves oblong-lanceolate, sagittately or hastately incised at base and with long peduncles. Habitat: "low grounds," "wet meadows and marshes," "moist banks and turfy meadows," in the Coastal plain from New England southward.

This interpretation of *V. sagittata* is well expressed by H. D. House, N. Y. State Mus. Bull. 243-244: 26 (1921) 1923, who in citing a plant of *V. sagittata* from near the Catskills said: "It is to be noted that this collection is the typical glabrous, slender form such as is found in the turfy meadows adjacent to the salt marshes of Long Island and southward."

It is probable that typical *V. sagittata* Ait does not occur in Ohio. The specimens in the State Herbarium and in the Oberlin College Herbarium, that have been examined, are more or less pubescent throughout, and should probably be designated *V. sagittata* Ait. var. *subsagittata* Farwell.

987. *V. fimbriatula* J. E. Smith (*V. ovata* Nutt.).

This has leaves equally pubescent on both sides, ovate to ovate-oblong, rather acute, crenate, often lacerately toothed at the base; flowers a "paler purple" or "bright blue" instead of the deep blue of *V. sagittata*. Habitat: barren soils, sandy fields and dry hillsides. This has been reported from nine counties in Ohio, all of them except Washington being in the northern part of the state. To these add Lorain.

986. *Viola emarginata* (Nutt.) Le Conte.

This, like typical *V. sagittata*, has leaves glabrous or slightly pubescent above, but differs in having the leaves almost triangular, the base being truncate or slightly cordate; peduncles longer than the leaves; petals deep violet-blue, frequently emarginate or bidentate.

To this Dr. Greene, Pittonia 3: 255-256, 1897, adds: "True *V. emarginata* differs from *V. sagittata* not only in the broad deltoid outline of its foliage, but also in a pronounced succulency. Specimens of *V. sagittata* under good treatment dry perfectly after three or four days, while those of *V. emarginata* require seven or eight days for drying."

The habitat and distribution of *V. emarginata* according to Britton's Manual are "fields and hillsides, New York to Virginia," according to Gray's Manual, 7th Ed., "dry woods and hillsides, New Jersey and southward," while Dr. Greene, Pittonia 3: 313, 1898, gives the distribution "in fairly typical condition" as from New York City "southward and southwestward to Louisiana and Eastern Texas."

This succulent plant with broad, deltoid, glabrous leaves seems thus to have much the same distribution as typical *V. sagittata*, and to be limited to the Atlantic and Gulf Coastal Plain. The question naturally arises as to the status of plants from Ohio and Michigan, which have been determined as *V. emarginata*.



O. A. Farwell, Papers Mich. Acad. Sci. 2: 32 (1922) 1923, discusses several plants collected by him near Detroit, one of which at least was seen by Dr. Greene and referred to *V. emarginata*. Farwell says, "Our plants are found in sandy soils, sometimes with no other vegetation, sometimes with a sparse growth of sedge grass. They are never entirely free from pubescence and never show the broad deltoid leaf characteristic of this species, but Dr. Greene said that they were nevertheless unmistakably this species."

Dr. Greene, Pittonia, 3: 313, 1898, referring to the first of the above plants which Farwell had previously labelled "*V. ovata*," said, "The leaves are all either exactly cordate-ovate or subsagittate-oblong; but in spite of this new leaf-cut, the plant is unmistakably *V. emarginata*." In view of their morphological characters, Farwell's treatment of his plants as forms of *V. ovata*, i. e., of *V. fimbriatula*, seems to be more nearly correct, especially since Nuttall himself described *V. ovata* as having "ovate, subcordate" leaves.

A plant from Lorain County in the Oberlin Herbarium, doubtfully referred to *V. emarginata* by Dr. Brainerd, conforms well to the description of Farwell's plants, and is here considered a form of *V. fimbriatula*.

The two plants in the State Herbarium, labelled *V. emarginata*, from Lake and Cuyahoga counties are loosely villous, with peduncles of the petaliferous flowers much shorter than the triangular-ovate leaves; capsules purple. They appear to be forms of *V. fimbriatula*, or segregates of *V. fimbriatula* X *sororia*.

— *Viola sagittata* var. *subsagittata* Farwell, Papers Mich. Acad. Sci. 2: 32 (1922) 1923.

This variety, according to Farwell, has the "arrow-shaped leaves" of *V. sagittata*, but is larger and pubescent, and is found in sandy fields. His variety is based, however, on *V. subsagittata* Greene, Pittonia 3: 315, 1898.

— *V. subsagittata* Greene.

This is described by Greene as "low, the very short-petioled leaves depressed or ascending; the whole plant at time of petaliferous flowering often only two inches high, more or less sparsely hirsute-pubescent, the sepals ciliate; vernal leaves rather narrowly cordate-ovate and small, three-fourths to one and one-fourth inches long, basal lobes almost closing the sinus; corolla very large, deep violet, often one inch long and ten or eleven lines wide, all petals white at base, the lower three densely white hairy at base, the hairs not clavellate." "Common in southern Wisconsin in rather low pasture and meadowlands, quite after the behavior of true *V. sagittata* at the East and South. By the side of true *V. sagittata* this western species appears quite dwarfed in all except its corolla, this being about twice as large as that of *V. sagittata*. But the plant has the pubescence of *V. ovata*. True *V. sagittata* seems to reach Central Illinois, and even the southern peninsula of Michigan; but I have not seen it from Wisconsin, nor *V. subsagittata* from any point to the southward or eastward of Wisconsin."

In spite of the fullness and clarity of this statement, Robinson and Fernald, Gray's Manual, 7th ed., p. 583, commenting on the distribution of *V. sagittata*, say: "In Ohio and westward a pubescent form of the species is prevalent (*V. subsagittata* Greene)."

Just what should be the taxonomic and nomenclatorial treatment of the so-called "pubescent form of *V. sagittata*," which occurs on dry, open soils in Ohio and elsewhere has not yet been satisfactorily determined. For the present it seems best to refer these plants to *V. sagittata* Ait. var. *subsagittata* Farwell—*V. sagittata* Pursh.—not *subsagittata* Greene.

The following nine hybrids represented by herbarium specimens are known from Ohio. Only four of them have been previously reported from the state.

982 x 980. *X cordifolia* (Nutt.) Schw., Am. Jour. Sci. 5: 62, 1822, as a species; H. D. House, N. Y. State Mus. Bull. 254: 504, 1924, as a hybrid.

—*V. hirsutula* X *papilionacea* Brainerd, Rhodora 9: 98, 211–216, 1907. Hamilton\* (Herb. E. Lucy Braun, Am. Midl. Nat. 15: 54, 1924); also Herb. Ezra Brainerd "from Ohio" (Vt. Agr. Expt. Sta. Bull. 239: 12, 1924). Add Lorain.\*

Wherever these two species occur together a population of hybrids and hybrid derivatives may be expected, which will show segregation and recombination of all the characters of the two parents.

For use of students of the Ohio Violets Brainerd's table (Rhodora 9: 211) of the differing characters is given here:

	<i>V. Hirsutula</i>	<i>V. papilionacea</i>
Habit.....	Nearly prostrate.....	Erect
Leaves.....	{Width.....	2–4 cm.....
	{Upper surface.....	Hirsutulous.....
	{Petioles.....	Glabrous.....
Flowers.....	{Color.....	Reddish purple.....
	{Spurred petal.....	Villous.....
	{Length.....	6–8 mm.....
Capsules.....	{Color.....	Purple.....
	{Number of seeds.....	20–30.....
	{Length.....	1.6 mm.....
Seeds.....	{Color.....	Buff.....
		Dark brown

Dr. Brainerd has shown that purple capsules and brown seeds are dominant over green capsules and buff seeds, and that the F hybrid is intermediate between the two parents in size of capsules and of seeds.

984 x 980. *X viola modica* House, N. Y. State Mus. Bull. 254: 500, 1924.

—*Viola palmata* X *papilionacea* Brainerd in herb.; Dowell, Bull. Torr. Bot. Club 37: 177, 1910; Brainerd, Bull. Torr. Club 39: 85–88, pls. 5–6, 1912; Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 153–155, pls. 64a, 64b, 1924.

Dowell (l. c.) says: "This differs from *V. palmata* in the direction of *V. papilionacea* by the more entire leaves, its scant pubescence, smaller

flowers on shorter peduncles, while it resembles *V. palmata* in having irregular shallow lobes on the leaves, veins prominent, and being more or less pubescent."

Brainerd (l. c.) says: "Leaves cordate-ovate as in *V. papilionacea*, lobed after the manner of *V. palmata*, but less deeply so; the capsules from cleistogamous flowers ovoid-conical, 5-7 mm. long, or half as long as the normal capsule in either parent, containing in the 48 capsules examined an average of  $4\frac{1}{2}$  seeds to the capsule." Lorain\* (four sheets of this hybrid and its derivatives).

In the three following hybrids, *V. palmata* X *sagittata* Brainerd, *V. sagittata* X *sororia* Brainerd, and *V. sagittata* X *triloba* Brainerd, the *sagittata* parent is the pubescent plant of dry open fields, and gravelly soils, i. e., the *V. sagittata* var. *subsagittata* of Farwell. However, it has seemed best to maintain Brainerd's terminology, until more careful studies have clarified the status and relations of *V. sagittata* Ait., *V. subsagittata* Greene and *V. sagittata* var. *subsagittata* Farwell.

984 x 988. *X viola mistura* House. N. Y. State Mus. Bull. 254: 500, 1924.

—*V. palmata* X *sagittata* Brainerd, *Rhodora* 15: 115, 1913; Vt. Agr. Expt. Sta. Bull. 239: 157, pl. 65, 1924.

House's diagnosis (l. c.): "Leaves ciliate and more or less pubescent, subcordate, with 6-8 acute slender lobes chiefly toward the base; capsules infertile."

Lorain\* and Erie (three sheets of this hybrid or its segregates).

988 x 981. *Viola sagittata* X *sororia* Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 193, pl. 78, 1924.

"Plants varying in leaf-outline from ovate with crenate-serrate margin, as in *V. sororia*, to lanceolate with hastate basal lobes, as in *V. sagittata*; varying also in like manner as respects other characters that differentiate the parent species."

Erie, collected with its putative parents in dry, gravelly soil, top of bluff near Birmingham.

988 x 983. *X viola caesariensis* House, N. Y. State Mus. Bull. 254: 506, 1924.

—*V. sagittata* X *triloba* Brainerd. *Rhodora* 15: 115, 1913; Vt. Agr. Expt. Sta. Bull. 239: 195, pl. 79, 1924; first described, *Rhodora* 8: 54, 1906, as *V. palmata* X *sagittata* Brainerd.

"Differing from *V. sagittata* in having wider pubescent leaf-blades more or less lobed near the middle, in having cleistogamous flowers with appressed ciliate auricles, and in having a brown-spotted summer capsule on much shorter peduncles; differing from *V. triloba* in having ovate-oblong leaves with coarsely toothed or incised basal lobes, and in having long slender cleistogamous flowers on ascending peduncles; in each case the difference being in the direction of qualities possessed by the other parent."

Lorain\* (a single plant annotated by Dr. Brainerd, as apparently a segregate from this hybrid).

984 x 981. *X Viola peckiana* House, N. Y. State Mus. Bull. 254: 500, 1924.

= *V. palmata* *X sororia* House, N. Y. State Mus. Bull. 243-244: 53 (1921) 1923; idem 254: 500, 1924.

House's diagnosis (l. c.): "Early leaves broadly ovate to reniform, entire or with some of the leaves slightly lobed, somewhat pubescent above, glabrous beneath and on the petioles; later leaves softly and rather densely pubescent on the petioles and lower leaf surfaces, the blades less pubescent above, variously 3-7-lobed or nearly entire; flowers abundant, but soon withering without developing fruit; capsules all from cleistogamous flowers on short, horizontal, or deflexed and buried peduncles. Growing with *V. palmata* and *V. sororia*."

Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 159, pl. 66, 1924, in discussing this hybrid, said: "About ten years ago I received from Miss E. Lucy Braun of Cincinnati, Ohio, specimens of an anomalous violet in flower, collected in 'dry woods, Hamilton County.' With this was sent a drawing of its mature leaves and fruit. The foliage in outline and pubescence is quite the same as in the hybrid here discussed." Hamilton\* (herb. E. Brainerd, l. c., p. 13). Add Lorain.

980 x 981. *X Viola napae* House, N. Y. State Mus. Bull. 254: 501, 1924.

= *V. papilionacea* *X sororia* Brainerd in herb.; Dowell, Bull. Torr. Bot. Club 37:178, 1910.

Dr. Dowell says: "This differs from *V. sororia* in having longer petioles, thinner leaves, and less pubescence, while it differs from *V. papilionacea* in being decidedly more or less pubescent."

Hamilton\* (herb. Ezra Brainerd, Vt. Agr. Expt. Sta. Bull. 239:169, 1921; herb. E. Lucy Braun, Am. Midl. Nat. 15: 54, 1934). Add Lorain.\*

970 x 967. *X Viola braunii* nom. nov.

= *V. rostrata* *X striata* Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 191, pl. 77, 1924.

Brainerd's diagnosis: "Outline of leaf-blade broadly ovate-cordate, acuminate; stipules slightly fimbriate as in *V. rostrata*; like *V. striata* in its thick, short, blunt spur and bearded lateral petals."

Dr. Brainerd described this hybrid from specimens collected by Miss E. Lucy Braun, May 27, 1917, and May 26, 1918, near Terrace Park, Hamilton\* Co., Ohio. At the same time she collected both parent species. Two sheets of this hybrid from Miss Braun's collections are in the Ezra Brainerd herbarium, (l. c., p. 14), and others in the herbarium of Miss Braun (Am. Midl. Nat. 15:54. 1934).

981 x 983. *X Viola populifolia* Greene, as a species, Pittonia 3: 337, 1898; House, N. Y. State Mus. Bull. 254: 502, 1924.

= *V. sororia* *X triloba* Brainerd, Torr. Bot. Club. Bull. 39: 92-93, 1912; Vt. Agr. Expt. Sta. Bull. 239: 199, pl. 8, 1924.

Greene (l. c.) says of *V. populifolia*: "An acaulescent blue-flowered woodland violet akin to *V. cuspidata* Greene [= *V. sororia*, according

to Brainerd], but smaller, petioles of the early leaves densely villous-hirsute, the blade from broad cordate in the very earliest and smallest, to deltoid or deltoid-reniform in those accompanying the petaliferous flowers, notably broader than long, both surfaces, but more conspicuously the lower, hirsute-pubescent, especially along the veins; . . ."

Brainerd (l. c.) says: "The shallow and obscure lobes of the hybrid are the same as in *V. papilionacea* *X* *triloba*, but the foliage is never glabrous." . . . "The leaf outline in *V. triloba* is relatively broader and less deeply cordate than in *V. sororia* (or in *V. papilionacea*), and the hybrid offspring may inherit the uncut leaves of the latter and the broad outline of the former, thus presenting a decidedly reniform leaf." Lorain.\* (Three sheets.)

---

#### New Versions of Well-Known Textbooks of Plant Physiology

The second edition of Miller's "Plant Physiology" is an enlargement and revision of the first edition which appeared in 1931. The general plan of the earlier edition has been retained. The increased size of the book is due chiefly to inclusion of the results of recent investigations. The bibliographies, a valuable feature of this book, are even more comprehensive in the present than in the earlier edition. This volume will undoubtedly continue to be the most useful modern reference textbook for advanced students, teachers, and investigators, but because of its length and encyclopedic presentation of subject matter is not well adapted for general classroom use.

"Plant Physiology," the English version of the Fifth Russian Edition of Maximov's textbook differs considerably from the earlier "A Textbook of Plant Physiology" (1930) which was based on the Second Edition of the Russian textbook. The current edition is not only more comprehensive than the earlier one but an entirely different and distinctive organization has been followed. The physico-chemical organization of the plant and its chemical compositions are first discussed, followed by chapters on respiration and growth. Next come five chapters dealing with fundamental plant processes. The last five chapters deal, in order, with the resistance of plants to unfavorable environmental conditions, correlations and vegetation propagation, physiology of development, physiology of reproduction, and seasonal phenomena in the life of plants. The author's intention is "to reproduce for the student as clearly as possible a complete picture of the life of the plant, not as a sum of separate physiological functions, but as a unified developing process beginning with the germination of seeds and terminating with the maturing of seeds newly reproduced by the plant." The reviewer is more in sympathy with the author's avowed purpose than he is with the organization which has been adopted in attempting to achieve that objective. Instead of leading the student on, step by step, and with ever-widening capacity for the interpretation of increasingly complex phenomena, the transition from subject to subject is often abrupt and psychologically illogical, so that the chapters must certainly appear as a series of only loosely related topics to the uninitiated student. The book does contain much sound and interesting information, and is quite worthwhile from this standpoint. The number of uncritical or misleading statements is greater, however, than should be tolerated in any introductory textbook.—*B. S. Meyer.*

**Plant Physiology**, 2nd Ed., by E. C. Miller. 1201 pp. New York, The McGraw-Hill book Co., 1938. \$7.50.

**Plant Physiology**, by N. A. Maximov, edited by R. B. Harvey and A. E. Murneek. 473 pp. New York, The McGraw-Hill Book Co., 1938. \$4.50.

## ARGIA FUMIPENNIS IN OHIO

MIKE WRIGHT,

Department of Zoology and Entomology,  
Ohio State University

The writer was quite surprised on the morning of January 31, 1939—with some snow still on the ground—to have presented to him a live male of *Argia fumipennis* Burmeister. Upon investigation it was discovered that this specimen was obtained from the Botany Greenhouse on the Ohio State University Campus in Columbus, Ohio. Two days later the nymphal exuvium was found clinging to the side of one of the glass aquaria.

Dr. G. W. Blaydes of the Botany Department of O. S. U. very kindly investigated the source from which the plants in these aquaria were obtained and found that they had been purchased from a firm in Tampa, Florida.

The literature shows that this species has been taken as far north as Kentucky (H. Garman, 1924). P. Garman (1917) states, "This species [*Argia fumipennis*] has not been reported from Illinois but has been reported from Kentucky, and may possibly be taken in southern Illinois." Borror (1937) does not list this species from Ohio.

The writer has captured numbers of *Argia fumipennis* in shaded woodland areas near running water at various localities in the Central Gulf Coast Region. This species seems to be rather distinctly a southern form. Its capture in central Ohio, even though bred in a greenhouse, is of interest as it shows one possible way in which the range of such an insect might be extended. If the environmental conditions were favorable, adults of a species which had been artificially transported, in the nymphal stage, to a region beyond its known range might there escape from the sheltered place, in which it had emerged, and oviposit in some suitable aquatic habitat. Then, if there were sufficient vegetation and depth of water present to prevent freezing of the immatures, it is quite probable that the species would become established in that region.

In addition, on March 13, 1939, a male of *Ischnura posita* Hagen and a female of *Ischnura verticalis* Say were taken in a different room in the Botany Greenhouse. Both of these species, however, are common inhabitants of Ohio.

#### LITERATURE CITED

- Borror, D. J. 1937. An Annotated List of the Dragonflies of Ohio. Ohio Jour. Sci. 37 (3): 185-196.  
Garman, H. 1924. Odonata from Kentucky. Ent. News. 35: 285-288.  
Garman, P. 1917. Zygoptera, or Damsel Flies, of Illinois. Bull. Ill. State Lab. Nat. History 12, article 4.
- 

#### Physical Meteorology

As the title indicates, in the book under review consideration is devoted primarily to the various physical aspects of meteorology and to the operation of those physical laws and principles producing or explaining the phenomena grouped under the general term "weather." In so far as such a treatment of the subject matter was the goal of the author he has been successful but, as will be evident from examples cited below, less success attended his efforts to provide mathematical justification for certain of the formulas and results appearing in the text.

In addition to a well written discussion of the standard subject matter of meteorology, the book contains particularly good popular accounts of the dynamics of motions in the atmosphere and of the theory and classification of extratropical cyclones. Here the author has written with an interest and enthusiasm which can scarcely fail to be shared by the reader; although the latter may deprecate the use of the outmoded law of Stokes rather than the corrected form of this law due to Cunningham and Millikan in the treatment of the settling of dust through the air, or the appearance of the statement made on page 194 in regard to the condition for convection to be initiated.

In this book, as in all modern physical texts, the importance of mathematical formulation of physical situations is clearly recognized and, as a result, the book cannot be read in its entirety without an understanding of at least the elements of differential and integral calculus. However, the mathematical portions of the text, are, to a considerable extent, additions to an otherwise complete treatment and, as such mathematical addenda are almost always printed in fine type, it is possible for the non-mathematical reader to avoid embarrassment. The device of printing mathematical discussions in small type has the further advantage of setting off those sections which appear to have been prepared with less care than the remainder of the book. For example, in the discussion of the escape of planetary atmospheres (page 14) the correct formula for the work done in removing a particle from the surface of a planet to infinity is obtained only by a fortunate combination of errors. In this connection, it seems worth while to note, on the one hand, that the recent papers of E. A. Milne and J. E. Jones have shown that the problem of escape of atmospheres is far too delicate to be solved by the argument presented in the text and, on the other hand, that there are excellent reasons for doubting the moon to be "quite devoid of any atmosphere."—L. LaPaz.

*Physical Meteorology*, by John G. Albright. xxvii+392 pp. New York, Prentice-Hall, Inc., 1938. \$5.35.

# PROTOZOAN PARASITES OF THE ORTHOPTERA, WITH SPECIAL REFERENCE TO THOSE OF OHIO

## II. DESCRIPTION† OF THE PROTOZOAN PARASITES RECOGNIZED IN THIS STUDY.‡

FRANK M. SEMANS,

The Ohio State University  
and  
Youngstown College

### MASTIGOPHORA

**Leptomonas** sp. (Plate I, Figs. 1 and 2.)

Hosts: *Parcoblatta virginica* (Brunner); *P. lata* (Brunner); *P. pen(n)sylvanica* (DeGeer).

Habitat: Hind-intestine.

Distribution: Champaign, Fairfield, Franklin, Hocking, Logan, Madison, and Washington Counties, Ohio.

Description: The organism is asymmetrically pyriform, 7.5 to 9 $\mu$  in length by 3 to 4.5 $\mu$  in width. The nucleus is granule-like. There is a single flagellum, 12 to 15 $\mu$  in length and the blepharoplast is indistinguishable from the base of the flagellum. Leishmania-like organisms are present which are ovoid in shape and approximately 5 by 4 $\mu$  in size, and possess two minute granule-like bodies (apparently nucleus and blepharoplast) and a short filament.

Affinities: By description (there is no illustration) this organism resembles *Leptomonas blaberae* Tejera, 1926, differing as to host (*Blabera* sp., Venezuela), length of flagellum (15 to 25 $\mu$ ), and slightly as to size (6.8 to 8 by 2.5 to 6 $\mu$ ).

Comment: It is inadvisable, because of insufficient characterization, to name this organism at the present.

### SPOROZOA

**Leidyana gryllorum** (Cuénot, 1897) Watson, 1916. (Plate I, Fig. 3.)

References: Cuénot, 1897a, 54; Labbé, 1899, 10; Cuénot, 1901, 594; Watson, 1916a, 120; Bhatia and Setna, 1924, 288.

Synonymy: *Clepsidrina gryllorum* Cuénot, 1897a, 54; *Gregarina macrocephala* Labbé, 1899, 10; *G. gryllorum* Cuénot, 1901, 594; *Leidyana gryllorum* Watson, 1916a, 120.

---

†All descriptions are made from types and paratypes on slide mounts in the author's collection.

‡Contributions from the Department of Zoology and Entomology, Number 112, Part II.



Hosts: *Gryllus assimilis* Fabricius; \**G. domesticus* (Linnaeus); \**G. spp.*; \**Nemobius sylvestris* (Bosc d'Antic); *N. fasciatus fasciatus* (DeGeer).

Habitat: \*Alimentary canal; \*gizzard; enteric ceca; \*\*mid-intestine.

Distribution: \*Ardennes, Nancy, Joinville, and Roscoff, France; \*Lahore, India; Franklin and Washington Counties, Ohio.

Description: The protomerite of this organism is a sphere, flattened posteriorly; the deutomerite is cylindric to tapering, terminating in a blunt point. There is a marked constriction at the septum. The epicyte and sarcocyte, collectively, are extremely thin over the entire surface. The endoplasm of the protomerite is moderately opaque and is white in reflected light; that of the deutomerite is somewhat more opaque in transmitted light. The nucleus is spherical and contains no karyosomes.

The measurements of the organism are as follows: Length and width of protomerite, 45 to 59 $\mu$  by 65 to 71 $\mu$ , averaging 52 by 68 $\mu$ ; of the deutomerite, 150 to 230 $\mu$  by 78 to 97 $\mu$ , averaging 190 by 87.5 $\mu$ . Total length of the organism is 195 to 289 $\mu$ , averaging 242 $\mu$ . The nucleus is 32 to 39 $\mu$  in diameter, averaging 35.5 $\mu$ . (For all of the Gregarinida, measurements were taken of the representative specimens.)

Proportions are as follows: Length of protomerite to total length varies from 1 : 4.3 to 1 : 4.9, averaging 1 : 4.6; width of protomerite to width of deutomerite varies from 1 : 1.2 to 1 : 1.4, averaging 1 : 1.3.

No movement was observed, the organism usually being attached to debris posteriorly.

Two cephalonts (with globular epimerites) were observed. No other stages were recognized.

Comment: Approximately five stages intermediate between *Leidyana gryllorum* (Cuénot) and *L. erratica* (Crawley) were observed, indicating that these species might be extreme types of the same species. This corroborates the observations of Bhatia and Setna (1924, 288), who doubted that these Leidyanae were distinct species. A more complete statement will be withheld until further work has been done in this direction.

**Leidyana erratica** (Crawley, 1907) Watson, 1915. (Plate I, Figs. 4, 5, 6.)

References: Crawley, 1903a, 45; Crawley, 1903b, 639, 641; Crawley, 1907, 221; Ellis, 1913c, 286; Watson, 1915, 35; Watson, 1916a, 118; Kamm, 1922a, 133; Bhatia and Setna, 1924, 288.

Synonymy: *Gregarina achetaeabbreviatae* Crawley, 1903a, 45; *Stephanophora erratica* Crawley, 1907, 221; *Leidyana solitaria* Watson, 1915, 35; *L. erratica* Watson, 1916a, 118.

Hosts: \*\**Gryllus assimilis* Fabricius; \**G. spp.*; *Nemobius fasciatus fasciatus* (DeGeer); *N. fasciatus socius* Scudder; *Anaxipha exigua* (Say); *Hapithus agitator agitator* Uhler.

Habitat: \*Alimentary canal; \*gizzard; \*\*enteric ceca; \*\*mid-intestine.

\*Of other investigators only.

\*\*Of the author as well as of other investigators

Unstarred information is of the author only.

Distribution: \*Lahore, India; \*Urbana, Illinois; \*Cold Spring Harbor and Oyster Bay, New York; Champaign, Franklin and Washington Counties, Ohio.

Description: The protomerite of this organism is diamond-shaped; the deutomerite is cylindric and broadly rounded posteriorly, or tapering, terminating in a point, which varies from blunt to sharp. There is little or no constriction at the septum. The epicyte and sarcocyte, collectively, are extremely thin over the entire surface. The endoplasm of the protomerite is moderately opaque, and is white to yellowish in reflected light; that of the deutomerite is somewhat more opaque. The nucleus is spherical and contains no karyosomes.

The measurements are as follows: Length and width of protomerite, 22 to 91 $\mu$  by 32 to 82 $\mu$ , averaging 49.5 by 57 $\mu$ ; of the deutomerite, 195 to 435 $\mu$  by 50 to 130 $\mu$ , averaging 303 by 97 $\mu$ . Total length of the organism, 217 to 526 $\mu$ , averaging 352.5 $\mu$ . Diameter of the nucleus, 15 to 58 $\mu$ , averaging 35 $\mu$ .

The proportions are as follows: Length of protomerite to total length varies from 1 : 5.8 to 1 : 9.6, averaging 1 : 7.3; width of protomerite to width of deutomerite varies from 1 : 1.2 to 1 : 2.2, averaging 1 : 1.7.

No movement was observed, the organism being almost invariably attached posteriorly to debris.

No other stages in the life cycle of the organism were recognized.

Comment: See comment for *Leidyana gryllorum*.

***Gregarina ohioensis* n. sp.** (Plate I, Fig. 7.)

Hosts: *Parcoblatta virginica* (Brunner).

Habitat: Mid-intestine.

Distribution: Franklin County, Ohio.

Description: The primate protomerite of this organism is dome-like, and the deutomerite, an elongate cylinder. The satellite protomerite is flattened, and the deutomerite, elongate, tapering posteriorly to a point. There is no constriction at the septum of the primate, little at that of the satellite. The epicyte and sarcocyte of the association, collectively, are 19 $\mu$  and less in thickness in the protomerites and 10 $\mu$ , becoming much thinner posteriorly, in the deutomerites. The endoplasm of the association is moderately opaque, and is white in reflected light. The nucleus in both primate and satellite is a sphere, somewhat compressed.

The measurements are as follows: Length and width of primate protomerite, 123 by 247 $\mu$ ; of primate deutomerite, 910 by 292 $\mu$ ; of satellite protomerite, 110 by 286 $\mu$ ; of satellite deutomerite, 1072 by 292 $\mu$ . Total length of primate, 1033 $\mu$ ; of satellite, 1182 $\mu$ . Total length of association, 2215 $\mu$ . Diameter of nuclei of primate and satellite, 65 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length, 1 : 8.4; of satellite, 1 : 10.7. Width of primate protomerite to width of deutomerite, 1 : 1.2; of satellite, 1 : 1.0.

No movement was observed.

---

\*Of other investigators only.

No other stages were recognized.

Affinities: This organism resembles a variety of *Gregarina blattarum* Siebold, 1839, perhaps a distinct species, described by M. E. Watson (1916b), differing from it as follows: The primate protomerite of *G. ohioensis* n. sp. is dome-like and there is no constriction of the primate; the primate protomerite of Watson's variety of *G. blattarum* S. is bluntly pointed and there is a perceptible constriction of the primate.

The organism also resembles *Gregarina illinensis* Watson, 1915, differing from it as follows: The posterior end of the satellite is pointed in *G. ohioensis* n. sp. and rounded in *G. illinensis* W. There is no primate constriction in *G. ohioensis*, a perceptible one in *G. illinensis*. Other lesser differences may be noted.

***Gregarina thomasi*§ n. sp. (Plate I, Fig. 8.)**

Hosts: *Parcoblatta pennsylvanica* (DeGeer).

Habitat: Enteric ceca; mid-intestine.

Distribution: Fairfield County, Ohio.

Description: The primate protomerite of the organism is an elongate, blunt cone, irregularly shaped, and the deutomerite is elongate and irregular, slightly tapering posteriorly. The satellite protomerite is flattened, and the deutomerite is elongate and irregular, tapering to a blunt point. There is no constriction at the septa. The epicyte and sarcocyte of the association are  $15\mu$  and less in thickness in the protomerites, and are extremely thin in the deutomerites. The endoplasm of the association is translucent, and is white in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primate protomerite, 162 to  $195\mu$  by 182 to  $195\mu$ , averaging 170 by  $187\mu$ ; of primate deutomerite, 710 to  $910\mu$  by 215 to  $260\mu$ , averaging 811 by  $237\mu$ ; of satellite protomerite, 71 to  $97\mu$  by 195 to  $218\mu$ , averaging 79 by  $207\mu$ ; of satellite deutomerite, 747 to  $845\mu$  by 227 to  $295\mu$ , averaging 792 by  $268\mu$ . Total length of primate, 872 to  $1105\mu$ , averaging  $981\mu$ ; of satellite, 818 to  $1592\mu$ , averaging  $871\mu$ . Total length of association 1690 to  $2697\mu$ , averaging  $1852\mu$ . Diameter of nuclei of primate and satellite,  $65\mu$  each.

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 4.6 to 1 : 6.6, averaging 1 : 5.65; of satellite, 1 : 10 to 1 : 12.7, averaging 1 : 11.35. Width of primate protomerite to width of deutomerite varies from 1 : 1.1 to 1 : 1.4, averaging 1 : 1.25; of satellite, 1 : 1.2 to 1 : 1.4, averaging 1 : 1.3.

The movement is slow, with twisting about debris in the path of the organism.

No other stages were recognized.

Affinities: This organism resembles *G. ohioensis* n. sp., differing from it as follows: The primate protomerite of *G. thomasi* n. sp. is an elongate, irregular, blunt cone; that of *G. ohioensis* n. sp. is dome-like. The primate deutomerite of *G. thomasi* n. sp. is irregular in shape and tapers slightly posteriorly; that of *G. ohioensis* n. sp. is regularly

---

§In honor of Edward S. Thomas, Curator of Natural History, Ohio Museum.

cylindrical. There is no constriction of the satellite in *G. thomasi* n. sp. while that in *G. ohioensis* is perceptible.

The organism differs from *G. blattarum* Siebold, Watson variety, in shape of primate protomerite, which is an elongate, irregular, blunt cone in *G. thomasi*, and is a papillate cone of moderate length in *G. blattarum*. There is a perceptible constriction of both primate and satellite in *G. blattarum*, none in *G. thomasi*.

The same differences are found when *G. thomasi* is compared with *G. illinensis* Watson, which has a primate protomerite which is broadly rounded and almost spherical, and which has perceptible constrictions of both primate and satellite. A number of lesser differences may be noted.

***Gregarina parcoblatiae* n. sp.** (Plate I, Figs. 9, 10, and 11.)

Hosts: *Parcoblatta uhleriana* (Saussure); *P. pennsylvanica* (DeGeer).

Habitat: Mid-intestine.

Distribution: Fairfield and Washington Counties, Ohio.

Description: The primate protomerite of the organism is flattened and regularly or irregularly rounded; the deutomerite is cylindric. The satellite protomerite is flattened, and the deutomerite is cylindric. There is a marked constriction at the septum of both primate and satellite. The epicyte and sarcocyte of the association are apparently extremely thin. The endoplasm of the association is very opaque, and is white in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primate protomerite, 90 to 130 $\mu$ , by 143 to 208 $\mu$ , averaging 112 by 174 $\mu$ ; of primate deutomerite, 390 to 553 $\mu$  by 215 to 325 $\mu$ , averaging 474 by 267 $\mu$ ; of satellite protomerite, 59 to 97 $\mu$  by 112 to 260 $\mu$ , averaging 78.5 by 185.5 $\mu$ ; of satellite deutomerite, 443 to 650 $\mu$  by 214 to 390 $\mu$ , averaging 549.5 by 289 $\mu$ . Total length of primate, 480 to 683 $\mu$ , averaging 586 $\mu$ . Total length of association, 982 to 1430 $\mu$ , averaging 1214 $\mu$ . Diameter of primate nucleus, 45 to 65 $\mu$ , averaging 55; of satellite nucleus, 45 to 65 $\mu$ , averaging 58 $\mu$ . Nuclei were sometimes invisible because of the opacity of the cell.

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 5.0 to 1 : 5.6, averaging 1 : 5.3; of satellite, 1 : 6.7 to 1 : 9.1, averaging 1 : 8.0. Width of primate protomerite to width of deutomerite varies from 1 : 1.4 to 1 : 1.8, averaging 1 : 1.6; of satellite, 1 : 1.2 to 1 : 1.8, averaging 1 : 1.5.

The movement is slow, without flexion. The organism is often attached posteriorly to debris.

Two cysts were observed. These were 290 $\mu$  in diameter, or 475 $\mu$  including the transparent outer layer. They were very opaque and were white in reflected light. Dehiscence was not observed. No other stages were recognized.

Affinities: This organism resembles *Gregarina blattarum* Siebold, Watson variety, differing as follows: The shape of the primate protomerite in *G. parcoblatiae* n. sp. is flattened and broadly rounded, regularly or irregularly; that of *G. blattarum* is papillate. The deutomerites of *G. parcoblatiae* are cylindric and square cornered; those

of *G. blattarum* are between cylindric and ovoid. Lesser differences can be seen.

***Gregarina rigida columna* n. subsp.** (Plate I, Figs. 12 (?), 13.)

Hosts: *Arphia sulphurea* (Fabricius); *Chortophaga viridifasciata* (DeGeer); *Encopitolophus sordidus* (Burmeister); *Pardalophora apiculata* (Harris); *Dissosteira carolina* (Linnaeus); *Spharagemon bolli* Scudder; *S. collare collare* (Scudder); *Melanoplus obovatipennis* (Blatchley); *M. scudderii scudderii* (Uhler); *M. differentialis* (Thomas); *M. bivittatus* (Say); *M. mexicanus mexicanus* (Saussure); *M. keeleri luridus* (Dodge).

Habitat: Enteric ceca; mid-intestine.

Distribution: Gary, Indiana; Fairfield, Franklin, Licking, Union, and Washington Counties, Ohio.

Description: The prime protomerite of the organism is dome-like; the deutomerite is cylindric. The satellite protomerite is somewhat flattened and is often continuous with the deutomerite; the deutomerite is cylindric. There is very little or no constriction at the septum of either prime or satellite. The epicyte and sarcocyte, collectively, of the association vary from 4 to 20 $\mu$  in thickness, usually being of uniform thickness throughout, but sometimes being much thicker in the prime protomerite. The endoplasm is moderately opaque and is yellow in reflected light. The nuclei are spherical and contain eight or more small karyosomes.

The measurements are as follows: Length and width of prime protomerite, 52 to 195 $\mu$  by 85 to 214 $\mu$ , averaging 117 by 157 $\mu$ ; of prime deutomerite, 165 to 780 $\mu$  by 97 to 292 $\mu$ , averaging 412 by 177 $\mu$ ; of satellite protomerite, 46 to 101 $\mu$  by 85 to 219 $\mu$ , averaging 60 by 141 $\mu$ ; of satellite deutomerite, 228 to 650 $\mu$  by 85 to 210 $\mu$ , averaging 384 by 147 $\mu$ . Total length of prime, 217 to 975 $\mu$ , averaging 529 $\mu$ ; of satellite, 274 to 751 $\mu$ , averaging 444 $\mu$ . Total length of association, 491 to 1726 $\mu$ , averaging 973 $\mu$ . Diameter of prime nucleus, 39 to 65 $\mu$ , averaging 58 $\mu$ ; of satellite nucleus, 39 to 67 $\mu$ , averaging 52 $\mu$ .

The proportions are as follows: Length of prime protomerite to total length varies from 1 : 3.7 to 1 : 6.1, averaging 1 : 5.5; of satellite, 1 : 5.0 to 1 : 7.7, averaging 1 : 6.1. Width of prime protomerite to width of deutomerite varies from 1 : 1.0 to 1 : 1.2, averaging 1 : 1.1; of satellite, 1 : 0.9 to 1 : 1.2, averaging 1 : 1.0.

The movement is slow and deliberate, without flexion.

For other stages in the life history, see *Gregarina rigida rigida* (Hall).

Affinities: This organism closely resembles *Gregarina rigida* (Hall), given in this paper as *G. rigida rigida* (Hall), differing from it as follows: The prime protomerite of *G. r. columna* is dome-like, almost as wide as that of the deutomerite, and has little or no constriction; that of *G. r. rigida* is flattened, usually much narrower than the deutomerite, and a constriction is always present, usually marked. The ratio of the width of the deutomerite to that of the protomerite was taken as the principal diagnostic character in setting apart these two subspecies. So far as can be determined from the illustrations of other investigators (most of the written descriptions are inadequate), the ratio 1 : 1.3 may be taken as the lower limit for *G. r. rigida*, Watson (1916a, 105) giving 1 : 1.4 as that of the typical organism. The mean width ratio of all

specimens of *G. r. rigida* observed in this study was 1 : 1.5. Ten percent of these showed a ratio of 1 : 1.3; ten percent 1 : 1.4; six percent 1 : 1.5; twelve percent 1 : 1.7 and four percent 1 : 1.8. The mean width ratio of all specimens of *G. r. columna* was 1 : 1.1 with eleven percent showing 1 : 1.0; twenty-six percent 1 : 1.1 and twenty-one percent 1 : 1.2.

Aside from the mean width ratios (not conclusive in themselves), a factor that might tend to support a distinction between the two subspecies is the fact that they are seldom found in the same individual host. Also, a distinctive tendency in some of the individuals of the 1 : 1.0 to 1.2 range is a lengthening of the protomerite of the primate, the ratio approximating 1 : 1 (length to width) in three of those observed, two of them with the 1 : 1.1 width ratio, and one with the 1 : 1.2.

The intergrading individuals represent a link between the two subspecies which makes it inadvisable at the present to raise *G. r. columna* n. subsp. to the specific rank.

***Gregarina rigida rigida* (Hall, 1907) Ellis, 1913. (Plate I, Fig. 14.)**

References: Hall, 1907, 150, 169, etc.; Crawley, 1907, 223; Sokolow, 1911, 279; Wellmer, 1911, 108; Ellis, 1913a, 464; Ellis, 1913b, 82; Ellis, 1913c, 267; Watson, 1915, 34; Watson, 1916a, 105; Kamm, 1920, 23.

Synonymy: *Hirmocystis rigida* Hall, 1907, 150, 169, etc.; *Gregarina melanopli* Crawley, 1907, 223; *Gregarina rigida* Ellis, 1913c, 267; *Gregarina rigida rigida* n. subsp.

Hosts: *Chorthippus curtipennis curtipennis* (Harris); *Arphia sulphurea* (Fabricius); *\*Encoptolophus sordidus* (Burmeister); *Dissosteira carolina* (Linnaeus); *Spharagemon bolli* Scudder; *\*Brachystola magna* (Girard); *\*Schistocerca americana americana* (Drury); *\*Hesperotettix viridis pratensis* (Scudder); *Melanoplus obovatipennis* (Blatchley); *\*\*M. differentialis* (Thomas); *\*\*M. bivittatus* (Say); *\*\*M. femur-rubrum femur-rubrum* (DeGeer); *\*\*M. mexicanus mexicanus* (Saussure); *\*\*M. keeleri luridus* (Dodge); *\*M. angustipennis* (Dodge).

Habitat: *\*Alimentary canal; gizzard; \*\*enteric ceca; mid-intestine.*

Distribution: *\*Canon City and Colorado Springs, Colorado; \*Urbana, Illinois; Gary, Indiana; \*Douglas Lake, Michigan; \*Lincoln, Nebraska; \*Oyster Bay, New York; Fairfield, Franklin, Licking, and Washington Counties, Ohio; \*Wyncote, Pennsylvania.*

Description: The primate protomerite of the organism is flattened and broadly rounded; the deutomerite is cylindric. The satellite protomerite is flattened and the deutomerite cylindric. There is a marked constriction at the septa. The epicyte and sarcocyte, collectively, are very thin and of even thickness throughout, except occasionally in the primate protomerite, where they may become as much as 20 $\mu$  in thickness. The endoplasm of the association is moderately opaque, and is yellow in reflected light. The nuclei are spherical,

\*Of other investigators only.

\*\*Of the author as well as of other investigators.

Unstarred information is of the author only.

containing 1 to 10 karyosomes, the exact number being difficult to determine because of the opacity of the nucleus.

The measurements are as follows: Length and width of primate protomerite, 52 to 130 $\mu$  by 72 to 170 $\mu$ , averaging 88 by 122 $\mu$ ; of primate deutomerite, 163 to 468 $\mu$  by 124 to 280 $\mu$ , averaging 288 by 177 $\mu$ ; of satellite protomerite, 39 to 71 $\mu$  by 72 to 208 $\mu$ , averaging 58 by 127 $\mu$ ; of satellite deutomerite, 182 to 650 $\mu$  by 97 to 260 $\mu$ , averaging 325 by 181 $\mu$ . Total length of primate, 215 to 598 $\mu$ , averaging 376 $\mu$ ; of satellite, 221 to 721 $\mu$ , averaging 383 $\mu$ . Total length of association, 436 to 1319 $\mu$ , averaging 759 $\mu$ . Diameter of primate nucleus, 39 to 78 $\mu$ , averaging 52 $\mu$ ; of satellite nucleus, 33 to 78 $\mu$ , averaging 53 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 3.7 to 1 : 5.9, averaging 1 : 4.3; of satellite, 1 : 3.9 to 1 : 11.0, averaging 1 : 6.7. Width of primate protomerite to width of deutomerite varies from 1 : 1.3 to 1 : 1.8, averaging 1 : 1.5; of satellite, 1 : 1.3 to 1 : 1.7, averaging 1 : 1.45.

No movement was observed. The organisms are usually attached posteriorly to debris.

Numerous cephalonts were observed. Each possessed a globular epimerite. Cysts, averaging 260 $\mu$  in diameter, or 325 $\mu$ , including the transparent outer layer, were seen. These were very opaque, and were shades of yellow in reflected light. (It was impossible to determine whether the cephalonts and cysts were of this subspecies or of *G. rigida columna* n. subsp.) Dehiscence of cysts was not observed.

Affinities: See *Gregarina rigida columna* n. subsp.

### ***Gregarina indianensis* n. sp. (Plate I, Figs. 15 and 16.)**

Hosts: *Chorthippus curtipennis* (Harris); *Melanoplus differentialis* (Thomas); *M. bivittatus* (Say); *M. mexicanus mexicanus* (Saussure).

Habitat: Enteric ceca; mid-intestine.

Distribution: Gary, Indiana.

Description: The primate protomerite of the organism is cylindric to conic, and is truncated anteriorly; the anterior end is invaginated. The primate deutomerite is cylindric. The satellite protomerite approximates that of the primate in shape; the deutomerite is cylindric to tapering posteriorly, ending bluntly. There is little or no constriction at the septum of the primate; that of the satellite is slight. The epicyte and sarcocyte, collectively, are extremely thin throughout. The endoplasm of the association is moderately opaque, and is shades of yellow in reflected light. The nuclei are spherical and each possesses two large karyosomes.

The measurements are as follows: Length and width of primate protomerite, 97 to 151 $\mu$  by 85 to 124 $\mu$ , averaging 128 by 101 $\mu$ ; of primate deutomerite, 228 to 357 $\mu$  by 104 to 176 $\mu$ , averaging 316 by 133 $\mu$ ; of satellite protomerite, 65 to 97 $\mu$  by 97 to 124 $\mu$ , averaging 78 by 114 $\mu$ ; of satellite deutomerite, 221 to 338 $\mu$  by 118 to 130 $\mu$ , averaging 294 by 124 $\mu$ . Total length of primate, 325 to 508 $\mu$ , averaging 444 $\mu$ ; of satellite, 286 to 435 $\mu$ , averaging 372 $\mu$ . Total length of association, 611 to 943 $\mu$ , averaging 816 $\mu$ . Diameter of each nucleus, 44 to 52 $\mu$ , averaging 48 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 3.4 to 1 : 3.8, averaging 1 : 3.5; of satellite, 1 : 4.0 to 1 : 6.2, averaging 1 : 4.85. Width of primate protomerite to width of deutomerite varies from 1 : 1.2 to 1 : 1.4, averaging 1 : 1.3; of satellite, 1 : 1.0 to 1 : 1.3, averaging 1 : 1.1.

No movement was observed. The organisms are usually attached posteriorly to debris.

Cephalonts were very numerous. Each has a cylindrical epimerite, terminating bluntly. The protomerite is wider at the anterior end than at the base, presenting every gradation from this condition to that of the adult. No additional stages in the life history were recognized.

Affinities: This organism bears a marked resemblance to *Gregarina nigra* Watson, 1915 and possibly there is a close relationship between them. The differences are as follows: The primate protomerite of *G. nigra* has a minute indentation at the apex; that of *G. indianensis* has the anterior end depressed. The epicyte is thickened at the anterior end of the protomerite in *G. nigra*, very thin throughout in *G. indianensis*. The nucleus of *G. nigra* contains many karyosomes and is not visible in vivo; that of *G. indianensis* contains two (rarely three) karyosomes and is visible in vivo. The endoplasm of *G. nigra* is more opaque than that of *G. indianensis*.

It is interesting to add here that Bush (1928, 153) describes a *Legeria* sp. from Natal (U. S. Africa) that very closely resembles the immature sporonts of *G. indianensis*. Also he describes an organism which he identifies as *G. nigra* which might be a close relative of *G. indianensis*. It would follow, then, that *Legeria* sp. Bush, 1928 might be the immature sporont of *G. nigra*, Natal variety. Apparently neither Watson nor Bush recognized the immature sporonts of *G. nigra*.

***Gregarina nigra* Watson, 1915. (Plate I, Fig. 17.)**

References: Watson, 1915, 33; Watson, 1916a, 116; Kamm, 1922a, 130; Kamm, 1922b, 84; Bush, 1928, 154 et al.

Synonymy: Name unchanged.

Hosts: \**Encoptolophus sordidus* (Burmeister); *Zonocerus elegans* (Thunberg); \**Lentula* sp.; \**Cyrtacanthacris ruficornis* (Fabricius); \**Melanoplus differentialis* (Thomas); \*\**M. femur-rubrum femur-rubrum* (DeGeer).

Habitat: \*Alimentary canal; mid-intestine.

Distribution: \*Pietermaritzburg, Natal; \*Urbana, Illinois; Washington County, Ohio.

Description: The primate protomerite of the organism is conic, with a small pit at the apex; the deutomerite is cylindric except at the extreme posterior end, where it becomes swollen. The satellites were immature (see illustration). There is no constriction at the septum of the primate and little at that of the satellites. The epicyte and sarcocyte, collectively, are extremely thin, without the characteristic thickening at the anterior end described by Watson. (It should be noted that the

\*Of other investigators only.

\*\*Of the author as well as of other investigators.

Unstarred information is of the author only.



only specimen of this species recognized was an association of three sporonts; one atypically elongate primate and two small satellites—a condition rarely observed in *Gregarina*.) The endoplasm of the primate is very opaque, and is yellow in reflected light; that of the satellites is translucent and practically colorless in reflected light. The nucleus of the primate was invisible, those of the satellites spherical, possessing many karyosomes.

The measurements are as follows: Length and width of primate protomerite, 75 by  $80\mu$ ; of primate deutomerite, 425 by  $100\mu$ ; of satellite protomerite 25 by 35 to  $40\mu$ ; of satellite deutomerite, 125 to  $140\mu$  by 35 to  $40\mu$ , averaging 132.5 by  $37.5\mu$ . Total length of primate,  $500\mu$ ; of satellite, 150 to  $165\mu$ , averaging  $137.5\mu$ . Total length of association,  $637.5\mu$ . Diameter of satellite nuclei, 15 to  $18\mu$ , averaging  $16.5\mu$ .

The proportions are as follows: Length of primate protomerite to total length, 1 : 6.7; of satellite, 1 : 6.0 to 1 : 6.6, averaging 1 : 6.3. Width of primate protomerite to width of deutomerite, 1 : 1.25; of satellite, 1 : 1.0.

No movement was observed.

No other stages in the life history were recognized.

***Gregarina locustae* Lankester, 1863. (Plate I, Fig. 18.)**

References: Leidy, 1853a, 239; Leidy, 1856, 47; Diesing, 1859, 730; Lankester, 1863, 94; Léger, 1897, 10; Labbé, 1899, 35; Crawley, 1903a, 54; Crawley, 1903b, 640; Crawley, 1907, 225; Ellis, 1913c, 268; Watson, 1916a, 100.

Synonymy: *Gregarina Locustae Carolinae* Leidy, 1853a, 239; *G. Locustae Carolinae* Leidy, 1856, 47; *G. fimbriata* Diesing, 1859, 730; *G. Locustae* Lankester, 1863, 94; *G. locustae carolinae* Labbé, 1899, 35; *Stephanophora locustae carolinae*† Crawley, 1903a, 54; *G. locustae carolinae* Crawley, 1907, 225; *G. locustae* Watson, 1916a, 100.

Hosts: \*\**Dissosteira carolina* (Linnaeus).

Habitat: \*Alimentary canal; mid-intestine.

Distribution: Gary, Indiana; \*Wyncote, Pennsylvania.

Description: The primate protomerite of the organism is greatly flattened and narrow; the deutomerite is cylindric. The satellite protomerite is similar to that of the primate, but is not flattened to the same extent; the deutomerite is cylindric. There is a marked constriction at the septum of both primate and satellite. The epicyte and sarcocyte of the association are extremely thin. The endoplasm is translucent, and is white in reflected light. The nuclei are spherical, with one karyosome each.

The measurements are as follows: Length and width of primate protomerite, 45 by  $111\mu$ ; of primate deutomerite, 280 by  $176\mu$ ; of satellite protomerite, 59 by  $97\mu$ ; of satellite deutomerite, 280 by  $163\mu$ . Total length of primate,  $325\mu$ ; of satellite,  $339\mu$ . Total length of association,  $664\mu$ . Diameter of nuclei (primate and satellite),  $46\mu$ .

\*Of other investigators only.

\*\*Of the author as well as of other investigators.

Unstarred information is of the author only.

†One word.

The proportions are as follows: Length of primate protomerite to total length, 1 : 7.2; of satellite, 1 : 5.7. Width of primate protomerite to width of deutomerite, 1 : 1.6; of satellite, 1 : 1.7.

No movement was observed.

No other stages in the life history were recognized.

**Gregarina kingi** Crawley, 1907. (Plate I, Fig. 19.)

References: Crawley, 1907, 221; Sokolow, 1911, 279; Ellis, 1913c, 271; Watson, 1916a, 106.

Synonymy: *Gregarina kingi* Crawley, 1907, 221; *Gigaductus kingi* Ellis, 1913c, 271.

Hosts: \*\**Gryllus assimilis* Fabricius.

Habitat: \*Alimentary canal; gizzard; enteric ceca; mid-intestine.

Distribution: \*Beach Haven, New Jersey; Franklin and Washington Counties, Ohio; \*Wyncote, Pennsylvania.

Description: The primate protomerite of the organism is dilated anteriorly and constricted at or below the middle; the deutomerite is a modified cylinder. The satellite protomerite is elongate and the deutomerite, cylindric to tapering posteriorly. There is a marked constriction at the septa. The epicyte and sarcocyte, collectively, are extremely thin throughout. The endoplasm is translucent, and is white in reflected light. The nuclei are spherical and contain one large karyosome each.

The measurements are as follows: Length and width of primate protomerite, 48 to 52 $\mu$  by 32 to 34 $\mu$ , averaging 50 by 33 $\mu$ ; of primate deutomerite, 91 to 100 $\mu$  by 32 to 34 $\mu$ , averaging 95.5 by 33 $\mu$ ; of satellite protomerite, 20 to 25 $\mu$  by 35 to 38 $\mu$ , averaging 22.5 by 36.5 $\mu$ ; of satellite deutomerite, 59 to 65 $\mu$  by 35 to 38 $\mu$ , averaging 62 by 36.5 $\mu$ . Total length of primate, 139 to 152 $\mu$ , averaging 145.5 $\mu$ ; of satellite, 79 to 90 $\mu$ , averaging 84.5 $\mu$ . Total length of association, 218 to 242 $\mu$ , averaging 230 $\mu$ . Diameter of nuclei (primate and satellite) 13 to 15 $\mu$ , averaging 14 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 2.8 to 1 : 3.1, averaging 1 : 2.95; of satellite, 1 : 3.6 to 1 : 3.9, averaging 1 : 3.75. Width of primate protomerite to width of deutomerite, 1 : 1.0; of satellite, 1 : 1.0.

Movement was not observed. All of the organisms were attached to debris, usually posteriorly.

No other stages in the life history were recognized.

**Gregarina galliveri** Watson, 1915. (Plate I, Fig. 20.)

References: Watson, 1915, 33; Watson, 1916a, 111; Kamm, 1922a, 130; Kamm, 1922b, 84.

Synonymy: Name unchanged.

Hosts: \*\**Gryllus assimilis* Fabricius; *Hapithus agitator agitator* Uhler.

Habitat: \*Alimentary canal; crop and gizzard; enteric ceca; mid-intestine.

Distribution: \*Oyster Bay, New York; Franklin and Washington Counties, Ohio.

---

\*Of other investigators only.

\*\*Of the author as well as of other investigators.

Unstarred information is of the author only.

Description: The primate protomerite of the adult is flattened and as wide as the deutomerite or wider; the deutomerite is cylindric, with undulation, to tapering posteriorly. The satellite protomerite is flattened and the deutomerite is cylindric to ellipsoid. There is little or no constriction at the septa. The epicyte and sarcocyte, collectively, are extremely thin throughout. The endoplasm of the association is moderately to considerably opaque and is shades of yellow in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primate protomerite, 30 to 52 $\mu$  by 52 to 130 $\mu$ , averaging 37.5 by 88 $\mu$ ; of primate deutomerite, 65 to 195 $\mu$  by 45 to 104 $\mu$ , averaging 144 by 74 $\mu$ ; of satellite protomerite, 26 to 45 $\mu$  by 45 to 97 $\mu$ , averaging 33 by 72.5 $\mu$ ; of satellite deutomerite, 85 to 247 $\mu$  by 52 to 130 $\mu$ , averaging 165 by 92 $\mu$ . Total length of primate, 95 to 247 $\mu$ , averaging 181.5 $\mu$ ; of satellite, 111 to 292 $\mu$ , averaging 198 $\mu$ . Total length of association, 206 to 539 $\mu$ , averaging 379.5 $\mu$ . Diameter of primate nucleus, 15 to 32 $\mu$ , averaging 22 $\mu$ ; of satellite nucleus, 15 to 30 $\mu$ , averaging 20 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 3.1 to 1 : 7.1, averaging 1 : 5.0; of satellite, 1 : 3.7 to 1 : 8.8, averaging 1 : 6.0. Width of primate protomerite to width of deutomerite varies from 1 : 0.65 to 1 : 1.0, averaging 1 : 1.0; of satellite, 1 : 1.0 to 1 : 1.5, averaging 1 : 1.2.

No movement was observed. All of the organisms were attached posteriorly to debris.

No other stages in the life history were recognized.

Comment: M. E. Watson (1916a, 111) states that the primate protomerite is always wider than the primate deutomerite. In approximately 25% of those examined in this study (from the same species of host) the widths of the two parts were the same.

***Gregarina hadenoeci* n. sp.** (Plate I, Fig. 21; Plate II, Fig. 22.)

Hosts: *Hadenoecus puteanus* Scudder.

Habitat: Mid-intestine.

Distribution: Washington County, Ohio.

Description: The primate protomerite of the organism is a depressed sphere; the deutomerite is slightly tapering posteriorly. The satellite protomerite is a depressed sphere; the deutomerite is modified top-like. There is a very deep constriction at the septum of both primate and satellite. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm of the association is translucent, and is almost colorless in reflected light. The nuclei are spherical and have no karyosomes.

The measurements are as follows: Length and width of primate protomerite, 52 to 65 $\mu$  by 71 to 100 $\mu$ , averaging 58.5 by 85.5 $\mu$ ; of primate deutomerite, 162 to 227 $\mu$  by 85 to 123 $\mu$ , averaging 194.5 by 104 $\mu$ ; of satellite protomerite, 39 $\mu$  by 65 to 91 $\mu$  (average of latter, 78 $\mu$ ); of satellite deutomerite, 111 to 260 $\mu$  by 85 to 150 $\mu$ , averaging 185 by 117.5 $\mu$ . Total length of primate, 214 to 292 $\mu$ , averaging 253 $\mu$ ; of satellite, 150 to 299 $\mu$ , averaging 225 $\mu$ . Total length of association, 364 to 591 $\mu$ , averaging 477 $\mu$ . Diameter of primate nucleus, 25 to 26 $\mu$ , averaging 25.5 $\mu$ ; of satellite nucleus (one visible), 26 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 4.1 to 1 : 4.5, averaging 1 : 4.3; of satellite, 1 : 4.8 to 1 : 7.7, averaging 1 : 6.25. Width of primate protomerite to width of deutomerite, 1 : 1.2; of satellite, 1 : 1.3 to 1 : 1.6, averaging 1 : 1.45.

No movement was observed.

Fourteen smaller sporonts were observed which were more top-like than the satellites (see illustration). No other stages were recognized.

Affinities: This organism resembles *Gregarina stygia* Watson, 1915, differing from it as follows: Sporonts of *Gregarina hadenoeci* n. sp. are tapering and top-like; those of *G. stygia* are barrel-shaped. The primate protomerite of *G. hadenoeci* is a depressed sphere; that of *G. stygia* is hemispherical. There is a deep constriction of the primate in *G. hadenoeci*, little in *G. stygia*. In *G. hadenoeci* the satellite deutomerite is wider than the primate deutomerite; in *G. stygia* it is usually narrower. Other minor differences may be noted.

***Gregarina proteocephala* n. sp.** (Plate II, Figs. 23, 24, 25.)

Hosts: *Ceuthophilus gracilipes* (Haldeman).

Habitat: Mid-intestine.

Distribution: Washington County, Ohio.

Description: The primate protomerite of the organism is protean, exhibiting a deep, anterior, cup-like depression; the deutomerite is barrel-shaped to slightly tapering posteriorly. The satellite protomerite is continuous with the deutomerite, the two combined compartments forming an ellipse. The degree of constriction at the primate septum varies with the protean activity of the protomerite; there is little or no constriction at the satellite septum. The epicyte and sarcocyte, collectively, are of even thickness throughout, varying from  $6.5\mu$  down to an extremely thin layer. The endoplasm of the association is moderately to considerably opaque and is white in reflected light. The nuclei are spherical and possess no karyosomes.

The measurements are as follows: Length and width of primate protomerite vary greatly as a result of the protean activity. (See illustration.) Length and width of primate deutomerite, 111 to  $195\mu$  by 91 to  $150\mu$ , averaging 137 by  $108\mu$ ; of satellite protomerite, 39 to  $97\mu$  by 85 to  $150\mu$ , averaging 165 by  $113\mu$ . Total length of primate, approximately 150 to  $312\mu$ , averaging  $205\mu$ ; of satellite, 169 to  $357\mu$ , averaging  $227\mu$ . Total length of association, approximately 319 to  $669\mu$ , averaging  $432\mu$ . Diameter of nuclei, 32 to  $39\mu$ , averaging  $33\mu$ .

The proportions are as follows: Length of satellite protomerite to total length varies from 1 : 3.2 to 1 : 4.5, averaging 1 : 3.7. Width of satellite protomerite to width of deutomerite varies from 1 : 1.0 to 1 : 1.2, averaging 1 : 1.05.

The movement is slow with much torsion and flexion; that of the primate protomerite is almost ameboid.

Seven immature sporonts, six retaining epimerites, were observed. They were not found in the same specimens (but were in the same species of host), but did not resemble sporonts of the only other gregarinid (*Gregarina ceuthophili* n. sp.) recognized by the author from the same

species of host. The epimerite was a short, blunt cylinder (see illustration). (M. E. Watson, 1916a, 115, states that the epimerite of *Gregarina stygia* Watson, which probably came from the same host, is knobbed and slightly stalked.) The entire cephalont, or immature sporont, was very translucent.

Affinities: This organism resembles the gregarinid parasites of the ceuthophili, particularly *Gregarina longiducta* Ellis, but may be definitely set apart from all of them by the protean activity of the primate protomerite.

Comment: It is interesting to note that this gregarinid was taken from four of twelve specimens of *Ceuthophilus gracilipes* (Haldeman) from Washington County, Ohio, but from none of the forty-four specimens of the same species of insect taken in Fairfield County, Ohio.

**Gregarina species.** (Plate II, Fig. 26.)

Hosts: *Ceuthophilus divergens* Scudder.

Habitat: Mid-intestine.

Distribution: Franklin County, Ohio.

Description: The primate protomerite of the organism is an elongate hemisphere, and the deutomerite is ovoid. The satellite protomerite is hemispherical and the deutomerite ovoid. There is little constriction at the septa. The epicyte and sarcocyte were not recognized, hence they are probably very thin. The endoplasm of the association is opaque, and is white in reflected light. The nuclei were not visible.

The measurements are as follows: Length and width of primate protomerite, 45 by 52 $\mu$ ; of primate deutomerite, 156 by 65 $\mu$ ; of satellite protomerite, 36 by 43 $\mu$ ; of satellite deutomerite, 90 by 59 $\mu$ . Total length of primate, 191 $\mu$ ; of satellite, 126 $\mu$ . Total length of association, 317 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length, 1 : 4.2; of satellite, 1 : 3.5. Width of primate protomerite to width of deutomerite, 1 : 1.3; of satellite, 1 : 1.4.

No movement was observed.

No other stages were recognized.

Affinities: This organism resembles *Gregarina consobrina* Ellis, differing from it in the length to width ratio of the deutomerites. In *Gregarina* sp. length of deutomerites is over twice the width; in *G. consobrina* length and width are approximately equal.

Comment: Insufficient characterization makes it inadvisable to name the apparently new species at this time.

**Gregarina ceuthophili** n. sp. (Plate II, Figs. 27 to 30.)

Hosts: *Ceuthophilus gracilipes* (Haldeman); *C. brevipes* Scudder; *C. divergens* Scudder.

Habitat: Mid-intestine.

Distribution: Fairfield, Franklin, Licking, and Washington Counties, Ohio.

Description: The primate protomerite of the organism is polymorphic, varying from an irregular hemisphere to a cone with a blunt apex; the deutomerite is ellipsoid to tapering anteriorly. The satellite

protomerite is almost hemispherical and is continuous with the deutomerite; the latter is ovoid and elongate, sometimes with marked posterior tapering. There is a marked constriction at the primate septum; none at the satellite septum. The epicyte and sarcocyte, collectively, are usually extremely thin, but may occasionally be as much as three microns in the primate protomerite. The endoplasm of the association is translucent to moderately opaque, and is white in reflected light. The nuclei are spherical, each containing one large karyosome.

The measurements are as follows: Length and width of primate protomerite, 28 to  $59\mu$  by 45 to  $71\mu$ , averaging 45 by  $62\mu$ ; of primate deutomerite, 111 to  $265\mu$  by 60 to  $117\mu$ , averaging 200 by  $92.5\mu$ ; of satellite protomerite, 20 to  $39\mu$  by 45 to  $111\mu$ , averaging 33 by  $85.5\mu$ ; of satellite deutomerite, 95 to  $337\mu$  by 52 to  $111\mu$ , averaging 249 by  $94\mu$ . Total length of primate, 139 to  $324\mu$ , averaging  $245\mu$ ; of satellite, 115 to  $376\mu$ , averaging  $282\mu$ . Total length of association, 254 to  $700\mu$ , averaging  $527\mu$ . Diameter of primate nucleus, 25 to  $39\mu$ , averaging  $33\mu$ ; of satellite nucleus, 25 to  $45\mu$ , averaging  $36\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 5.0 to 1 : 6.0, averaging 1 : 5.4; of satellite, 1 : 5.7 to 1 : 9.6, averaging 1 : 8.2. Width of primate protomerite to width of deutomerite, 1 : 1.25 to 1 : 1.7, averaging 1 : 5.0; of satellite, 1 : 1.0 to 1 : 1.3, averaging 1 : 1.1.

The movement is rapid and in a straight line.

Numerous immature sporonts were recognized. They are characterized by the shape of the protomerite (a depressed sphere) and an elongate and tapering deutomerite. Several intergradations between this condition and that of the associated sporonts were observed. Ten cysts (same species?) were observed. These were spherical and averaged  $215\mu$  in diameter, not including the transparent outer layer, which was  $30\mu$  in thickness. Three cysts, kept in a thin film of water in a moist chamber, were reduced approximately  $80\mu$  in diameter, and were attacked by a mold after three days of observation. Dehiscence failed to take place. No other stages were recognized.

Affinities: This organism resembles several of the gregarinid parasites of the ceuthophili, particularly *Gregarina neglecta* Watson, differing from it as follows: The primate protomerite of *G. ceuthophili* n. sp. is irregularly hemispherical to conic with a blunt apex; that of *G. neglecta* is cap-like, very short and continuous with the deutomerite, and papillate at the apex. *G. ceuthophili* may have a marked constriction at the septum; *G. neglecta* has little or no constriction. The satellite deutomerite is elongate in *G. ceuthophili*; obese in *G. neglecta*. Minor differences may be noted.

### ***Gregarina prima* n. sp. (Plate II, Fig. 31.)**

Hosts: *Ceuthophilus uhleri* Scudder.

Habitat: Mid-intestine.

Distribution: Fairfield and Logan Counties, Ohio.

Description: The primate protomerite of the organism is a depressed hemisphere; the deutomerite is cylindric to ovoid. The satellite

protomerite is flattened and the deutomerite cylindric. A thick hyaline connective is present between the primate and satellite—a condition unique among the gregarinids described in this paper. There is a slight constriction at the septum of the primate, a deep one at that of the satellite. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm of the association is moderately opaque, and is white in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primate protomerite, 30 to  $66\mu$  by 48 to  $52\mu$ , averaging 49 by  $51\mu$ ; of primate deutomerite, 77 to  $127\mu$  by 57 to  $97\mu$ , averaging 108 by  $78\mu$ ; of satellite protomerite, 18 to  $30\mu$  by 52 to  $60\mu$ , averaging 23 by  $55\mu$ ; of satellite deutomerite,  $97\mu$  by 75 to  $77\mu$  (average of latter,  $76\mu$ ). Length of primate, 107 to  $193\mu$ , averaging  $157\mu$ ; of satellite, 115 to  $127\mu$ , averaging  $120\mu$ . Total length of association, 222 to  $320\mu$ , averaging  $277\mu$ . Diameter of nuclei, 14 to  $19\mu$ , averaging  $16\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 2.8 to 1 : 3.5, averaging 1 : 3.3; of satellite, 1 : 4.2 to 1 : 6.4, averaging 1 : 5.3. Width of primate protomerite to width of deutomerite varies from 1 : 1.5 to 1 : 1.9, averaging 1 : 1.7; of satellite, 1 : 1.25 to 1 : 1.5, averaging 1 : 1.4.

No movement was observed.

No additional stages were recognized.

Affinities: This organism resembles *Gregarina udeopsyllae* Watson, differing from it as follows: The primate protomerite of *G. prima* is a depressed hemisphere; that of *G. udeopsyllae* is papillate. *G. prima* has little constriction at the septum of the primate; *G. udeopsyllae* has a marked constriction. Minor differences may be noted.

***Gregarina acrydiinarum* n. sp.** (Plate II, Figs. 32 to 35.)

Hosts: *Acrydium arenosum angustum* Hancock; *Paratettix cucullatus cucullatus* (Burmeister).

Habitat: Mid-intestine.

Distribution: Delaware and Franklin Counties, Ohio.

Description: The primate protomerite of the organism is somewhat protean, but is usually cylindric, terminating bluntly; the deutomerite is ovoid to cylindric. The satellite protomerite is flattened almost to the point of obliteration; the deutomerite is ellipsoid to cylindric. There is a marked constriction at each of the septa. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm of the association is translucent and is shades of yellow to orange in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primate protomerite, 26 to  $45\mu$  by 32 to  $52\mu$ , averaging 36 by  $40\mu$ ; of primate deutomerite, 104 to  $169\mu$  by 65 to  $136\mu$ , averaging 137 by  $96\mu$ ; of satellite protomerite (omitting length, which is negligible), 30 to  $54\mu$  (width), averaging  $47\mu$ ; of satellite deutomerite, 143 to  $208\mu$  by 70 to  $143\mu$ , averaging 174 by  $96\mu$ . Length of primate, 130 to  $214\mu$ , averaging  $173\mu$ ; of satellite, 143 to  $208\mu$ , averaging  $174\mu$ . Total length of association, 273 to  $422\mu$ , averaging  $347\mu$ . Diameter of nuclei, 23 to  $32\mu$ , averaging  $29\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 4.3 to 1 : 6.1, averaging 1 : 4.9. Width of primate protomerite to width of deutomerite varies from 1 : 2.0 to 1 : 2.6, averaging 1 : 2.4; of satellite, 1 : 1.3 to 1 : 2.8, averaging 1 : 2.1.

The movement of the organism as a whole is a very slow gliding with some flexion. The primate protomerite is protean to the extent of bending and wrinkling like the flexible snout of some mammals. It always becomes cheese-box-like (Fig. 35) when fixed and stained.

Six cysts, spherical and of the same color as the sporonts, were observed, but were mashed under the cover-slip. This was the only time which this accident occurred with the cysts of gregarinids, which are usually very resistant. No other stages were recognized.

Affinities: This organism somewhat resembles *Gregarina ovata* Dufour, differing from it chiefly as follows: The primate protomerite of *G. acrydiinarum* is cylindric; that of *G. ovata* is a depressed sphere. The satellite protomerite of *G. acrydiinarum* is almost obliterated; that of *G. ovata* is somewhat flattened. The satellite deutomerite of *G. acrydiinarum* is ellipsoid to cylindric; that of *G. ovata* is ovoid.

### *Gregarina oviceps* Diesing, 1859. (Plate II, Fig. 36.)

References: Leidy, 1853a, 238; Leidy, 1856, 47; Diesing, 1859, 728; Lankester, 1863, 94; Labbé, 1899, 35; Crawley, 1903a, 45; Crawley, 1903b, 639; Crawley, 1907, 220; Ellis, 1913c, 266; Watson, 1915, 34; Watson, 1916a, 101; Bhatia and Setna, 1924, 287.

Synonymy: *Gregarina Achetae abbreviatae* Leidy, 1853a, 238; *G. oviceps* Diesing, 1859, 728; *G. Achetae* Lankester, 1863, 94; *G. achetaeabbreviatae* Labbé, 1899, 35; *G. achetae-abbreviatae* Crawley, 1907, 220.

Hosts: *Gryllus assimilis* Fabricius; *Gryllus* spp.

Habitat: \*Alimentary canal; \*\*gizzard; \*\*mid-intestine.

Distribution: \*Lahore, India; \*Urbana, Illinois; \*Douglas Lake, Michigan; \*Beach Haven, New Jersey; \*Oyster Bay, New York; Franklin and Washington Counties, Ohio; \*Haverford, Philadelphia, and Wyncote, Pennsylvania.

Description: The primate protomerite of the organism is flattened and wide; the deutomerite is ovoid and obese. The satellite protomerite is a modified hemisphere; the deutomerite ovoid and obese. There is a marked constriction at the septum of the primate, little at that of the satellite. The epicyte and sarcocyte, collectively, of the association are extremely thin. The endoplasm of the association is very opaque and is white to yellowish in reflected light. The nuclei were not visible.

The measurements are as follows: Length and width of primate protomerite, 65 to 71 $\mu$  by 150 to 180 $\mu$ , averaging 68 by 165 $\mu$ ; of primate deutomerite, 150 to 195 $\mu$  by 160 to 180 $\mu$ , averaging 177.5 by 170 $\mu$ ; of satellite protomerite, 70 to 71 $\mu$  by 105 to 117 $\mu$ , averaging 70.5 by 111 $\mu$ ; of satellite deutomerite, 175 to 228 $\mu$  by 160 to 193 $\mu$ , averaging 201.5 by 172.5 $\mu$ . Length of primate, 215 to 266 $\mu$ , averaging 245.5 $\mu$ ; of satellite,

\*Of other investigators only.

\*\*Of the author as well as of other investigators.

Unstarred information is of the author only.



245 to 299 $\mu$ , averaging 272 $\mu$ . Total length of association, 460 to 565 $\mu$ , averaging 517.5 $\mu$ .

The proportions are as follows: Length of primate protomerite to total length varies from 1 : 3.3 to 1 : 3.7, averaging 1 : 3.5; of satellite protomerite, 1 : 3.5 to 1 : 3.7, averaging 1 : 3.6. Width of primate protomerite to width of deutomerite varies from 1 : 1.0 to 1 : 1.01; of satellite, 1 : 1.5 to 1 : 1.6, averaging 1 : 1.55.

No movement was observed.

No other stages were recognized.

***Pileocephalus tachycines* n. sp.** (Plate II, Figs. 37 to 39.)

Hosts: *Tachycines asinamorus* (Adelung).

Habitat: Mid-intestine.

Distribution: Franklin County, Ohio.

Description: The protomerite is usually a depressed hemisphere; the deutomerite is usually irregularly ovoid to cylindric. There is a marked to slight constriction at the septum. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm is very opaque and is white in reflected light. The nucleus is spherical and contains one very large karyosome.

The measurements are as follows: Length and width of protomerite, 16 to 39 $\mu$  by 35 to 65 $\mu$ , averaging 24 by 44 $\mu$ ; of deutomerite, 91 to 121 $\mu$  by 55 to 85 $\mu$ , averaging 106 by 64 $\mu$ . Total length of the organism, 107 to 160 $\mu$ , averaging 130 $\mu$ . Diameter of nucleus, 20 to 32 $\mu$ , averaging 26 $\mu$ .

The proportions are as follows: Length of protomerite to total length varies from 1 : 3.8 to 1 : 6.8, averaging 1 : 5.5; width of protomerite to width of deutomerite varies from 1 : 1.3 to 1 : 1.6, averaging 1 : 1.5.

There is usually no movement; when it occurs it is very slow.

Three cephalonts were recognized. The epimerite is a modified cone, the protomerite a modified depressed hemisphere with apical depression and lateral constriction. One cyst was observed. This was spherical, 130 $\mu$  in diameter (transparent envelope not present), very opaque, and white in reflected light. No additional stages were recognized.

Affinities: This organism resembles *Pileocephalus blaberae* (Frenzel), differing chiefly as follows: The epimerite of *P. tachycines* is a modified cone; that of *P. blaberae* is lance-like and swollen at the base. The sporont of *P. tachycines* is not over 160 microns in length; the average length of *P. blaberae* is 500 microns.

***Actinocephalus* species.** (Plate II, Fig. 40.)

Hosts: *Pardalophora apiculata* (Harris).

Habitat: Mid-intestine.

Distribution: Washington County, Ohio.

Description: The "protomerite" is flattened and truncated; the "deutomerite" is a compressed sphere. (The tail-like posterior extension—see illustration—might have been a temporary cellular compression, as would be suggested by the presence of numerous parallel myoneme-like structures lying closely contiguous.) There is no con-

striction in the region of a possible septum. (Apparently this organism—one specimen observed—possesses no septum. The opacity would make it difficult to see the septum in vivo, but it failed to appear after the organism had been stained and permanently mounted.) The epicyte and sarcocyte, collectively, are about  $3\mu$  in thickness throughout. The endoplasm is very opaque, and is white in reflected light. The nucleus is a flattened sphere, containing 4 large karyosomes.

The measurements are as follows: Length and width of "protomerite," 110 by  $195\mu$ ; of "deutomerite," 680 by  $290\mu$ . Total length of organism,  $790\mu$ . Size of nucleus, 78 by  $97\mu$ .

The proportions are as follows: Length of "protomerite" to total length, 1:7.2; width of "protomerite" to width of "deutomerite," 1:1.5.

The movement is a very slow gliding in a straight line.

No other stages were recognized.

Affinities: All known characters, except the apparent lack of a septum, would indicate a close relationship between this organism and the other actinocephali of Orthoptera.

### **Actinocephalus elongatus** n. sp. (Plate II, Figs. 41 to 43.)

Hosts: *Dichromorpha viridis* (Scudder); *Arphia sulphurea* (Fabricius); *Chortophaga viridifasciata* (DeGeer); *Schistocerca americana americana* (Drury) (*A. elongatus* n. sp., ?); *Melanoplus mexicanus mexicanus* (Saussure) (*A. elongatus* n. sp. ?).

Habitat: Celom; enteric ceca; mid-intestine.

Distribution: Fairfield, Franklin, and Washington Counties, Ohio.

Description: The protomerite is usually a depressed hemisphere; the deutomerite is elongate, tapering irregularly to a blunt point. There is little or no constriction at the septum. The epicyte and sarcocyte, collectively, are from 6 to  $26\mu$  in thickness in the protomerite and about  $6\mu$  (average) in the deutomerite. The endoplasm is very opaque (usually black) and is white in reflected light. The nucleus is spherical and contains no karyosomes.

The measurements are as follows: Length and width of protomerite, 65 to  $130\mu$  by 130 to  $202\mu$ , averaging 100 by  $163\mu$ ; of deutomerite, 306 to  $682\mu$  by 111 to  $200\mu$ , averaging 482 by  $165\mu$ . Total length of organism, 371 to  $812\mu$ , averaging  $582\mu$ . Diameter of nucleus, 45 to  $62\mu$ , averaging  $54.5\mu$ .

The proportions are as follows: Length of protomerite to total length varies from 1:5.0 to 1:7.5, averaging 1:5.8; width of protomerite to width of deutomerite varies from 1:0.9 to 1:1.2, averaging 1:1.0.

No movement was observed. The organism is usually attached posteriorly to debris.

One cephalont was observed. This possessed a broad epimerite with a number of short, finger-like processes (10 perceptible). No other stages were recognized.

Affinities: This organism resembles *Actinocephalus fimbriatus* (Diesing), differing as follows: The protomerite of *A. elongatus* is a depressed hemisphere; that of *A. fimbriatus* is an almost perfect sphere.

The deutomerite of *A. elongatus* is elongate, tapering irregularly to a blunt point; that of *A. fimbriatus* is ovoid, tapering slightly.

### INFUSORIA

*Nyctotherus ovalis* Leidy, 1850, variety? (Plate II, Fig. 44.)

References: Siebold, 1839, 69; Leidy, 1850, 100; Leidy, 1853b, 244; Leidy, 1853c, 41; Stein, 1854, 42; Leidy, 1856, 43; Stein, 1856, 36; Claparède and Lachmann, 1858, 240; Stein, 1859, 78, 84, 85, 90; Stein, 1860, 50; Stein, 1862; Stein, 1867, 344; Leidy, 1879, 204; Grassi, 1881, 197; Schuster, 1898, 244; Belar, 1916, 242; Zulueta, 1916, 5; Kudo, 1922, 113; Yakimoff and Miller, 1922a, 9; Yakimoff and Miller, 1922b, 133; Pinto, 1926, 14; Tejera, 1926, 1382; Bhatia and Gulati, 1927, 86, 113, 116; Lucas, 1927, 224, 232; Lucas, 1928, 161; Weill, 1929, 22; McAdow, 1931, 16; Balch, 1932, 237.

Synonymy: "Leucophrys-artiges Infusorium" Siebold, 1839, 69; *Nyctotherus ovalis* Leidy, 1850, 100; *Bursaria blattarum* Stein, 1854, 42; *Plagiotoma Blattarum* Claparède and Lachmann, 1858, 240; *Plagiotoma blattarum* Stein, 1859, 78 et al.

Hosts: \**Blattella germanica* (Linnaeus); *Parcoblatta pensylvanica* (DeGeer); \**Blatta orientalis* Linnaeus; \**Periplaneta americana* (Linnaeus); \**Gryllotalpa gryllotalpa* Linnaeus; \*undetermined species of wood-cockroaches.

Habitat: \*Alimentary canal; \*mid-intestine; \*\*hind-intestine; \*colon; \*rectum.

Distribution: \*Brazil; \*London, England; \*French Indo-China; \*Berlin, Germany; \*Lahore, India; \*Urbana, Illinois; \*Ohio; Campaign County, Ohio.

Description: The organism is ovoid in shape with cilia uniformly distributed over the body. Its measurements are 78 to 104 $\mu$  by 104 to 136 $\mu$ . The peristome starts just back of the anterior end, bending laterally to the right and paralleling the anterior end, and then extends posteriorly a little over half way down the organism. The peristome of the typical *N. ovalis* Leidy is at right angles to that of this organism, starting just back of the anterior end, extending posteriorly, then bending laterally to the left.

A cytostome was not visible.

A cytopyge is present at the extreme posterior end, extending somewhat laterally. It averages about 20 $\mu$  in length.

One large vacuole (19 $\mu$ , maximum diameter) is present, usually in the region of the cytopyge, sometimes farther anterior. Two or three smaller vacuoles, varying greatly in size, are scattered throughout the posterior half of the organism. These were not seen in vivo, hence it is not known which were contractile.

The macronucleus is usually elongate (about 19 by 45 $\mu$ ), somewhat dumb-bell shaped, with its longitudinal axis at right angles to that of

\*Of other investigators only.

\*\*Of the author as well as of other investigators.

Unstarred information is of the author only.

the organism. The macronucleus of the typical *N. ovalis* approximates a fusiform appearance.

The micronucleus was not visible.

Affinities: This organism may be a variety of *N. ovalis*, or possibly a distinct species. However, only a limited amount of material for identification was available, as it was found in only one host (of 70 specimens of Blattidae).

#### SUMMARY

Fourteen newly described species and one new subspecies of protozoan parasites were recognized in this study, in addition to nine species which had been previously described by other investigators. Twenty-two (or twenty-four?) new hosts were named and new parasites were added for twelve (or ten?) orthopteran hosts which had been previously studied by others. (The exact number is uncertain because of certain incorrect host determinations made by other investigators.)

#### LITERATURE CITED

- Balch, H. E. 1932. The cultivation of *Nyctotherus ovalis* and *Endamoeba blattae*. Science, 76: 237.
- Belar, K. 1916. Protozoenstudien 2. Arch. Protistenk., 36: 241-302.
- Bhatia, B. L. and Setna, S. 1924. On some new cephaline gregarines. Parasitology, 16: 279-288.
- Bhatia, B. L. and Gulati, A. N. 1927. On some parasitic ciliates from Indian frogs, toads, earthworms and cockroaches. Arch. Protistenk., 57: 85-120.
- Bush, S. F. 1928. A study on the gregarines of the grasshoppers of Pietermaritzburg, Natal. Ann. Natal Mus. Pieterm., 6: 97-169.
- Claparède, E. and Lachmann, J. 1858. Études sur les infusoires et les rhizopodes. Mem. Inst. Nat. Genev., 5: 1-260.
- Crawley, H. 1903a. List of the polycystid gregarines of the United States. Proc. Acad. Nat. Sci. Phila., 55: 41-58.
- 1903b. The polycystid gregarines of the United States (second contribution). Proc. Acad. Nat. Sci. Phila., 55: 632-644.
1907. The polycystid gregarines of the United States (third contribution). Proc. Acad. Nat. Sci. Phila., 59: 220-228.
- Cuénot, L. 1897a. Évolution des grégaires coelomiques du grillon domestique. C. R. Acad. Sci. Paris, 125: 52-54.
- 1897b. Double emplois du nom de genre *Diplocystis* parmi les protozoaires. Zool. Anz., 20: 209-210.
1901. Recherches sur l'évolution et la conjugaison des grégaires. Arch. Biol., 17: 581-652.
- Diesing, C. M. 1859. Revision der Rhyngodeen. Anz. Akad. Wiss. Wien—Sitzungsb., 37: 719-782.
- Ellis, M. M. 1913a. New gregarines from the United States. Zool. Anz. 41: 462-465.
- 1913b. Gregarines from some Michigan Orthoptera. Zool. Anz., 43: 78-84.
- 1913c. A descriptive list of the cephaline gregarines of the new world. Trans. Amer. Micr. Soc., 32: 259-296.
- Grassi, B. 1881. Intorno ad alcuni protisti endoparassitici ed appartenenti alle classi dei flagellati, lobosi, sporozoi e ciliati. Atti Soc. Ital. Sci. Nat. Mus. Civ. Milano, 24: 135-224.
- Hall, M. C. 1907. A study of some gregarines with especial reference to *Hirmocystis rigida* n. sp. Univ. Studies, Univ. Nebraska, 7: 149-174.

- Kamm, M. W.** 1920. The development of gregarines and their relation to the host tissues: (3) in *Gregarina rigida* (Hall) Ellis. Jour. Parasit., 7: 23-28.
- 1922a. A list of new gregarines described from 1911 to 1920. Trans. Amer. Micr. Soc., 41: 122-152.
- 1922b. Studies on gregarines II. Illinois Biol. Monog., 7, no. 1: 1-104.
- Kudo, R.** 1922. The parasitic Protozoa of *Blatta orientalis* and their value as the material for use in a class of parasitic Protozoa. Anat. Rec., 23: 113.
- Labbé, A.** 1899. Sporozoa—das Tierreich, 5: 1-180.
- Lankester, E. R.** 1863. On our present knowledge of the Gregarinidae. Quart. Jour. Micr. Sci., 3: 83-96.
- Léger, L.** 1897. Nouvelles recherches sur les polycystidées parasites des arthropodes terrestres. Ann. Fac. Sci. Marseille, 6.
- Leidy, J.** 1850. Two new species of infusorial Entozoa. Proc. Acad. Nat. Sci. Phila., 5: 100.
- 1853a. On the organization of the genus *Gregarina* of Dufour. Trans. Amer. Phil. Soc. Phil., 10: 233-240.
- 1853b. Some observations on nematoidea imperfecta, and descriptions of three parasitic infusoriae. Trans. Amer. Phil. Soc. Phila., 10: 241-244.
- 1853c. A flora and fauna within living animals. Smithson. Contr. Knowl., 5: Article 2.
1856. A synopsis of Entozoa and some of their ectocongeners observed by the author. Proc. Acad. Nat. Sci. Phila., 8: 42-58.
1879. On *Amoeba blattae*. Proc. Acad. Nat. Sci. Phila., 1879: 204-205.
- Lucas, C. L. T.** 1927. Two new species of *Amoeba* found in cockroaches: with notes on the cysts of *Nyctotherus ovalis* Leidy. Parasitology, 19: 223-235.
1928. A study of excystation in *Nyctotherus ovalis* with notes on other intestinal protozoa of the cockroach. Jour. Parasit., 14: 161-175.
- McAdow, C. M.** 1931. Observations on some protozoa parasitic in cockroaches. M.A. thesis, The Ohio State University, MS.
- Pinto, C. F.** 1926. *Nyctotherus* dos blattídeos do Brasil. Bol. Biol. S. Paulo, 1: 14-16.
- Schuster, E. H. J.** 1898. On a new flagellate protozoan of the genus *Lophomonas*. Proc. Zool. Soc. London, 1898: 242-244.
- Semans, F. M.** 1936. Protozoan parasites of the Orthoptera, with special reference to those of Ohio. I. Introduction and methods. Ohio Journ. Science, 36: 315-320.
- Siebold, C. T. von.** 1839. Beiträge zur Naturgeschichte der wirbellosen Thiere. Über *Medusa*, *Cyclops*, *Loligo*, *Gregarina* und *Xenos*. Neueste Schr. Naturf. Ges. Danzig, 3.
- Sokolow, B.** 1911. Liste des grégarines décrites depuis 1899. Zool. Anz., 38: 277-295, 304-314.
- Stein, F.** 1854. Die Infusionsthier auf ihre Entwicklungsgeschichte untersucht.
1856. Über die ihm bisher bekannt gewordenen und von ihm genauer erforschten Infusionsthier, . . . Abh. Böhmisch. Ges. Wiss., (5) 10: 35-38.
1859. Der Organismus der Infusionsthier. Abth. 1.
1860. Beitrag über die bisher unbekannt gebliebene *Leucophrys patula* Ehb. und über zwei neue Infusoriengattungen *Gyrocoris* und *Lophomonas*. Abh. Böhmisch. Ges. Wiss., 1: 44-50.
1862. Amtl. Ber. der Karlsbader Naturforscherver. S. 166. (Original not available. Data from Stein, 1867.)
1867. Der Organismus der Infusionsthier. Abth. 2.
- Tejera, E.** 1926. Les blattes envisagées comme agents de dissémination des germes pathogènes. C. R. Soc. Biol. Paris, 95: 1382-1384.
- Watson, M. E.** 1915. Some new gregarine parasites from Arthropoda. Jour. Parasit., 2: 27-36.
- 1916a. Studies on gregarines. Illinois Biol. Monog., 2, no. 3: 1-258.
- 1916b. Observations on polycystid gregarines from Arthropoda. Jour. Parasit., 3: 65-75.
- Weill, R.** 1929. Notes protistologiques indochinoises. (1). Arch. Zool. Exp. et Gen., 69: Notes et Revue: 12-37, 41-54.
- Wellmer, L.** 1911. Sporozoen ostpreussischer arthropoden. Schr. Phys. Ökon. Ges. Königsberg, 52: 103-164.

- Yakimoff, W. L. and Miller, G. A. 1922a. Les protozoaires de l'intestin de l'homme en dehors de l'organisme de l'homme. L'examen de l'intestin du *Periplaneta orientalis*. Bull. Soc. Path. Exot. Paris, 15: 8-11.  
 1922b. Über die Darmprotozoen von *Periplaneta orientalis*. Russkii Arkhiv Protistologii, 1: 131-133.  
 Zulueta, A. de. 1916. Sobre la estructura y biparticion de *Nyctotherus ovalis* Leidy. Trab. Mus. Cienc., Serie Zoologica 26.

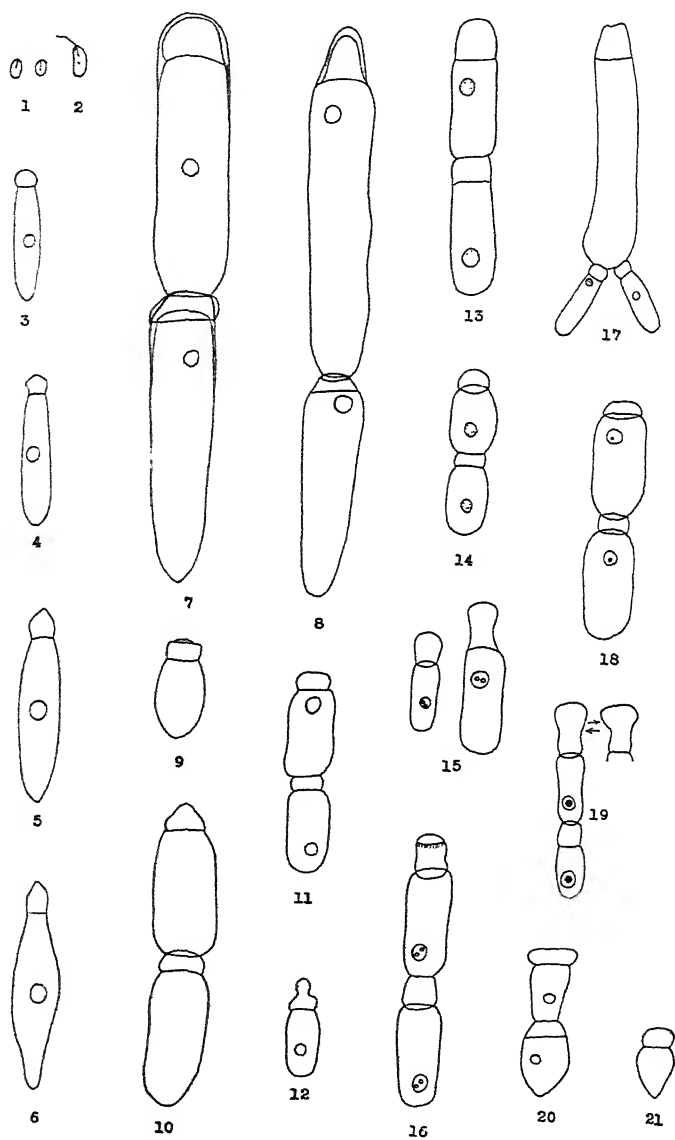
## EXPLANATION OF PLATES

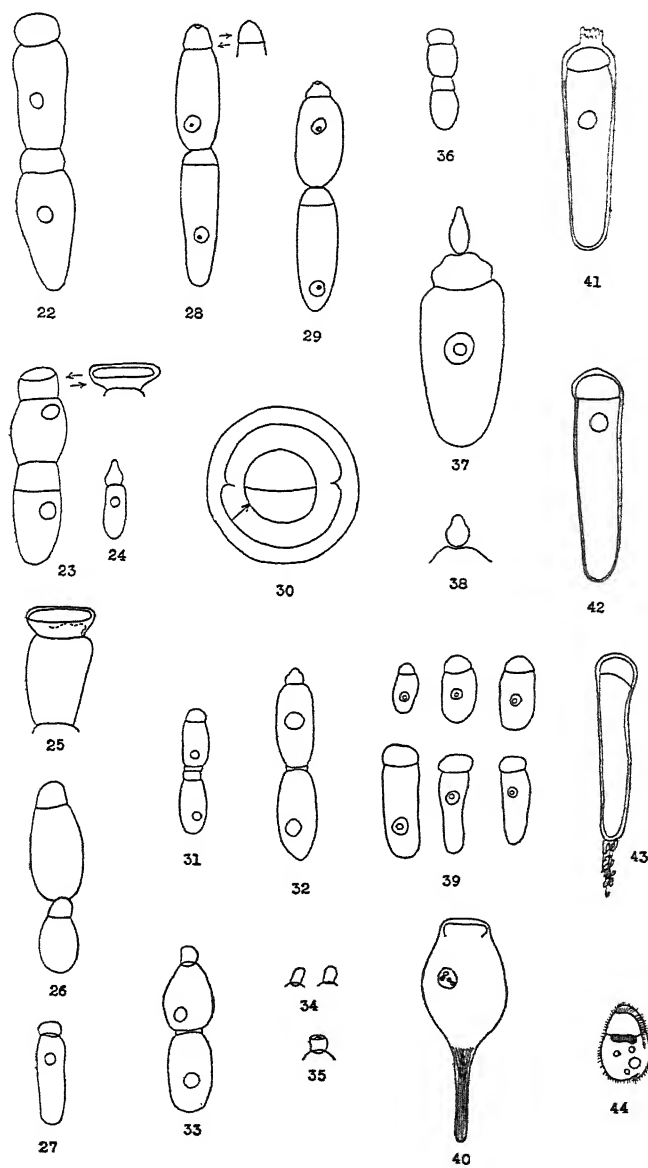
## PLATE I

- Fig. 1. *Leptomonas* sp., *Leishmania* stage?  
 Fig. 2. *Leptomonas* sp., *Leptomonas* stage.  
 Fig. 3. *Leidyana gryllorum* (Cuénot), adult sporont.  
 Figs. 4, 5, 6. *Leidyana erratica* (Crawley), adult sporonts.  
 Fig. 7. *Gregarina ohioensis* n. sp., adult association.  
 Fig. 8. *Gregarina thomasi* n. sp., adult association.  
 Fig. 9. *Gregarina paracoblattae* n. sp., immature sporont.  
 Figs. 10, 11. *Gregarina paracoblattae* n. sp., adult associations.  
 Fig. 12. *Gregarina rigida columna* n. subsp. or *G. r. rigida* (Hall) (?), cephalont.  
 Fig. 13. *Gregarina rigida columna* n. subsp., adult association.  
 Fig. 14. *Gregarina r. rigida* (Hall), adult association.  
 Fig. 15. *Gregarina indianensis* n. sp., immature sporonts.  
 Fig. 16. *Gregarina indianensis* n. sp., adult association.  
 Fig. 17. *Gregarina nigra* Watson (atypical as to width-length proportions), association of one adult and two immature sporonts.  
 Fig. 18. *Gregarina locustae* Lankester, adult association.  
 Fig. 19. *Gregarina kingi* Crawley, small adult association.  
 Fig. 20. *Gregarina galliveri* Watson, adult association.  
 Fig. 21. *Gregarina hadenoeci* n. sp., immature sporont.

## PLATE II

- Fig. 22. *Gregarina hadenoeci* n. sp., adult association.  
 Fig. 23. *Gregarina proteocephala* n. sp., adult association.  
 Fig. 24. *Gregarina proteocephala* n. sp., cephalont (of this species?).  
 Fig. 25. *Gregarina proteocephala* n. sp., primitive adult association, showing another occasional shape.  
 Fig. 26. *Gregarina* sp., adult association.  
 Fig. 27. *Gregarina ceuthophili* n. sp., immature sporont.  
 Figs. 28, 29. *Gregarina ceuthophili* n. sp., adult associations.  
 Fig. 30. *Gregarina ceuthophili* n. sp., cyst (of this species?), illustrating amount of shrinkage in three days. Arrows indicate shrinkage.  
 Fig. 31. *Gregarina prima* n. sp., adult association.  
 Figs. 32, 33. *Gregarina acrydiinarum* n. sp., adult associations.  
 Fig. 34. *Gregarina acrydiinarum* n. sp., primitive protomerites, illustrating characteristic change of shape.  
 Fig. 35. *Gregarina acrydiinarum* n. sp., primitive protomerite after fixing and staining.  
 Fig. 36. *Gregarina oviceps* Diesing, small association (probably immature).  
 Fig. 37. *Pileocephalus tachycines* n. sp., cephalont.  
 Fig. 38. *Pileocephalus tachycines* n. sp., epimerite of another shape.  
 Fig. 39. *Pileocephalus tachycines* n. sp., sporonts (of adult age approximately).  
 Fig. 40. *Actinocephalus* sp., adult sporont.  
 Fig. 41. *Actinocephalus elongatus* n. sp., cephalont.  
 Figs. 42, 43. *Actinocephalus elongatus* n. sp., adult sporonts (adhering to debris in Fig. 43).  
 Fig. 44. *Nyctotherus ovalis* Leidy (probably a variety).







## BOOK NOTICES

---

### Sedimentary Petrography

This is a revised edition of Professor Tickell's book, which first appeared in 1931. It is essentially a manual of laboratory practice in the field of sedimentary petrography, presenting methods selected from the techniques developed not only by geologists, but also by investigators in other fields such as hydrology, chemical engineering, ceramics, and petroleum engineering. Successive chapters are devoted to size analysis, porosity and permeability, preparation of specimens, identification of minerals, and description of detrital minerals.

The only notable difference between this and the first edition is in the chapter on porosity and permeability, which has been rewritten in enlarged and improved form. Elsewhere there are only minor changes and additions, and for the chapter on size analysis the revision has been decidedly inadequate. Since 1931 extensive progress has been made in many fields of investigation concerned with the problems of size analysis, and the author's cognizance of this new material has been casual, to say the least. This chapter might well have been rewritten just as thoroughly as the one on porosity, not only for the addition of new and important material, but also to correct a certain lack of balance among important topics. For example, space is taken for types of curves that are rarely, if ever useful to the student of sediments, and a larger number of curves is represented than actually necessary in a work of this size, whereas no directions are given for the preparation of the frequency distribution curve, a bothersome question for the neophyte in sedimentary analysis. Another element missing in this chapter is treatment of the problem, highly important to the geologist, of disaggregating sedimentary rocks for size analysis.

The chapters on mineral identification contain much valuable material and should serve well as a guide to anyone who has had at least an introduction to the microscopic techniques involved, but that they would provide means of salvation for "one who has the ordinary scientific fundamentals" (to quote the author) without any special training in optical mineralogy may well be doubted. As basis for a laboratory course in the subject, with competent instruction, they should serve admirably.

Probably no single book could contain all that the laboratory student of sediments might desire, nor present the subject from all desirable points of view. Among the works now available, Professor Tickell's book should be on the shelf of every serious worker in sedimentary petrology.—*Edmund M. Spieker.*

**The Examination of Fragmental Rocks**, revised edition, by Frederick G. Tickell. x+154 pp. Stanford University Press, 1939. \$4.00.

---

### Another Biology Textbook

This book has a number of excellent features. Nearly every phase of biology (except animal behavior) is discussed. There is a brief but complete survey of the animal and plant kingdoms, and the various systems and processes in living organisms are discussed on a comparative basis. Human biology is stressed in the chapters on animals. Separate chapters are devoted to the ecology and economic importance of plants and animals, to applied biology, and to biochemical and biophysical processes—subjects often omitted from elementary texts. There is a very complete glossary, and an index of Latin and Greek word roots, features which will be appreciated by both student and instructor. At the end of each chapter is a list of review questions. The book is well bound, and is printed on the new "eye-toned" paper.

Even with its desirable features this book is disappointing. The author has attempted to cover too much ground, and as a result the treatment of most subjects is very sketchy. The discussion is teleological. The book contains many state-

ments that are either inaccurate or misleading; for example, in Chapter 8, in characterizing the triploblastic phyla of animals is the statement, "The body wall is triploblastic, being made of three cellular layers, ectoderm, mesoderm, and endoderm;" in characterizing the phylum Chordata, p. 159, is the statement, "Pharyngeal clefts (gill slits) are present for respiration purposes at some stage of the life history;" in illustrating predaciousness, p. 499, is the statement, "Chicken hawks are predacious on chickens." The illustrations in the book, except for a few that are borrowed, are very poor. In discussing the various organ systems in animals, the author does little more than list the structures composing these systems in 28 representative animals.

Except in the chapter on heredity (which is one of the best chapters in the book), the experimental approach to biological problems and principles is almost never used. Almost nothing in the way of experimental data, from which the student might draw his own conclusions, is given. Such an approach would seem particularly appropriate in the discussions of physiology, ecology, and evolution.

—D. J. Borror.

**Fundamentals of Biology**, by William C. Beaver. 896 pp. St. Louis, The C. V. Mosby Co., 1939. \$4.50.

---

### Essays in Philosophical Biology

Friends of the late William Morton Wheeler have gathered together some of his occasional papers and published them in book form. Reprints of some of the articles were exhausted and for many none existed. Consequently the publication of this volume fills the need of preserving these articles for posterity. All present day biologists are acquainted with his many contributions to science, but many may not have had the opportunity of reading some of the papers presented in this volume.

The contents by chapters are as follows: The Ant-Colony as an Organism; Jean-Henri Fabre; On Instincts; The Termitodoxa, or Biology and Society; The Organization of Research; The Dry-Rot of Our Academic Biology; Emergent Evolution and the Development of Societies; Carl Akeley's Early Work and Environment; Present Tendencies in Biological Theory; Hopes in the Biological Sciences; Some Attractions of the Field Study of Ants; Animal Societies. A foreword by Thomas Barbour and an obituary by his colleagues precedes the essays. An excellent photograph of Dr. Wheeler forms the frontispiece.

This volume should be read from cover to cover by every biologist, both young and old. It reflects the knowledge and philosophy of one who has achieved much in science. All the essays are excellent but it seems that the reviewer would be doing an injustice if he did not recommend especially the one entitled "The Dry-Rot of Our Academic Biology." This is cleverly written and reflects the inimitable style of Dr. Wheeler.—R. H. Davidson.

**Essays in Philosophical Biology**, by William Morton Wheeler, selected by Prof. G. H. Parker. xv+261 pp. Harvard University Press, Cambridge, Massachusetts, 1939. \$3.00.

---

### The Sun

This book is a translation of the book "Il Sole," by an Italian. It is a remarkable book in many ways, in its virtues and in its faults, both of which it possesses in good measure. Its chief virtues are that it is well written and profusely illustrated. It has, in fact, 157 illustrations in 350 pages. The style is straightforward and non-technical so that the reader with only a general scientific background can follow the presentation easily and profitably.

The faults of the book may be divided into two groups, those due to the publisher and those due to the author. Among the former are the following: The book is printed in glazed paper which catches the light and glares abominably into the reader's eyes. The index is inexcusably incomplete. Among the faults which may be laid to the author are, first, that too great an emphasis has been laid upon the Royal Observatory (Italian) at Arcetri. The reader distinctly gets the impression

that there are other observatories elsewhere but that the most important one is that of the author. Only passing mention is made of the work of the McMath-Hulbert Observatory of the University of Michigan which is generally conceded to represent the most outstanding development in solar observatories of recent times.

The same may be said of Mr. Abetti's discussion of diffraction gratings. Mt. Wilson Observatory furnished Mr. Abetti with a grating. This was in itself rather unusual, because Mt. Wilson Observatory does not make many gratings for other than its own use. The grateful author makes no reference either to R. W. Wood of Johns Hopkins or H. G. Gale of the University of Chicago, both of whom toil to supply the scientific world with gratings.

In short, Mr. Abetti creates the impression that he is a scholar and a master of his subject in spite of being insulated from the rest of the world. In the face of these rather harsh comments, the reviewer wishes to recommend the book, particularly to those who wish to read a well written, earnest account of what is known about our nearest star.—*C. E. Hesthal*.

**The Sun**, by Georgio Abetti, translation by Alexandre Zimmerman and Frans Borghouts. 360 pp. New York, D. Van Nostrand Co., 1938. \$5.00.

# THE OHIO JOURNAL OF SCIENCE

Vol. XXXIX

JULY, 1939

No. 4

ANNUAL REPORT  
OF THE  
OHIO ACADEMY OF SCIENCE  
Forty-ninth Meeting  
1939

## TABLE OF CONTENTS

	PAGE
OFFICERS AND COMMITTEEMEN FOR 1939-1940.....	186
REPORT OF THE FORTY-NINTH ANNUAL MEETING.....	187
Introductory.....	187
Business Session.....	187
Reports of Officers:	
Secretary.....	190
Treasurer.....	191
Report of Auditor.....	192
Reports of Committees:	
Trustees of the Research Fund.....	193
Executive.....	194
Membership.....	195
Joint Administrative Board of Ohio Journal of Science.....	196
Library.....	197
To Co-operate with Ohio Department of Education.....	198
Conservation.....	199
Election of Fellows.....	205
Necrology.....	205
Nominating.....	211
Resolutions.....	211
PRESIDENTIAL ADDRESS—Claude E. O'Neal.....	213

# THE OHIO ACADEMY OF SCIENCE

Organized 1891

Incorporated 1892

Affiliated with the American Association for the Advancement of Science

## OFFICERS AND COMMITTEES FOR 1939-1940

### *President*

WILLIAM LLOYD EVANS

### *Director for Semi-Centennial, 1940*

DEAN GEORGE F. ARPS

### *Vice-Presidents*

- |   |   |
|---|---|
| A. <i>Zoology</i> : JOHN W. PRICE             | F. <i>Physics and Astronomy</i> :       |
| B. <i>Botany</i> : MISS LOIS LAMPE            | RAY LAMBERT                             |
| C. <i>Geology</i> : OTTO C. VON SCHLICTEN     | G. <i>Geography</i> : GEORGE D. HUBBARD |
| D. <i>Medical Sciences</i> : GEORGE M. CURTIS | H. <i>Chemistry</i> : PAUL ROTHMUND     |
| E. <i>Psychology</i> : FLOYD C. DOCKERAY      | I. <i>Mathematics</i> : LEWIS BRAND     |

### *Secretary*

WILLIAM H. ALEXANDER

### *Treasurer*

EUGENE VAN CLEEF

### *Executive Committee*

*Ex-Officio*: WM. LLOYD EVANS, WM. H. ALEXANDER, EUGENE VAN CLEEF

*Elective*: CLAUDE E. O'NEAL AND J. PAUL VISSCHER

### *Trustees Research Fund*

- |   |      |
|---|------|
| HERBERT OSBORN, <i>Chairman</i> , term expires..... | 1941 |
| JAMES P. PORTER, term expires.....                  | 1940 |
| CHARLES G. SCHATZER, term expires.....              | 1942 |

### *Library Committee*

MRS. ETHEL M. MILLER, *Chairman*,

In charge of Academy Exchanges and Publications

- |                                      |      |
|--------------------------------------|------|
| GEORGE D. HUBBARD, term expires..... | 1940 |
| E. LUCY BRAUN, term expires.....     | 1941 |

### *Academy Representatives*

- |  |                      |
|--|----------------------|
| (1) On Joint Administrative Board, O. J. S.: |                      |
| WALTER H. BUCHER, term expires.....          | 1940                 |
| A. W. LINDSEY, term expires.....             | 1941                 |
| (2) On Council of A. A. A. S. ....           | WILLIAM H. ALEXANDER |
| (3) On Save Outdoor Council. ....            | ROSCOE W. FRANKS     |

### *Committee on Conservation*

- |   |      |
|---|------|
| A. E. WALLER, <i>Chairman</i> , term expires..... | 1942 |
| F. H. KRECKER, term expires.....                  | 1940 |
| W. E. STOUT, term expires.....                    | 1940 |
| WALTER A. TUCKER, term expires.....               | 1940 |
| G. W. CONREY, term expires.....                   | 1941 |
| E. L. WICKLIFF, term expires.....                 | 1941 |
| PAUL B. SEARS, term expires.....                  | 1941 |
| EMERY R. HAYHURST, term expires.....              | 1942 |
| L. E. HICKS, term expires.....                    | 1942 |

### *Nominating Committee for 1940*

- |                                       |                     |
|---------------------------------------|---------------------|
| A. ROBERT A. HEFNER                   | E. JAMES R. PATRICK |
| B. PAUL B. SEARS                      | F. LEON E. SMITH    |
| C. W. STORRS COLE                     | G. FRED A. CARLSON  |
| D. LINDEN F. EDWARDS, <i>Chairman</i> | H. HARVEY V. MOYER  |
| I. CARL VER STEEG                     |                     |

# REPORT OF THE FORTY-NINTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

WILLIAM H. ALEXANDER,  
*Secretary*

The Forty-ninth Annual Meeting of the Ohio Academy of Science, held on the campus of the University of Cincinnati, Cincinnati, Ohio, on April 14-15, 1939, formed a very appropriate climax to the vigorous, aggressive administration of President Claude E. O'Neal, of Ohio Wesleyan University, Delaware, Ohio. Although the weather was persistently unfavorable throughout the entire meeting, the attendance was good and the enthusiasm notably fine. The committee in charge of the local arrangements, under the untiring, watchful leadership of Prof. J. Hobart Hoskins, apparently anticipated the many needs of the academy and the several sections down to the smallest detail and made ample provision for all. But what else was to be expected of the University of Cincinnati! Few, if any, institutions are better equipped for just such service than said University of Cincinnati! Again, "a thousand thanks, and we are much obliged besides!"

Under the skillful leadership of the President, the business portion of the meeting was limited to one session, held in the auditorium of McMicken Hall, on Friday morning. A fairly complete stenographic report of this meeting was made and is on file with the secretary, but for economic reasons only the chief items of business transacted are given below.

## I. The President announced the following committee appointments:

1. *Resolutions*—ARTHUR T. EVANS, Chairman; CLYDE S. ADAMS, RODERICK PEATTIE.
2. *Necrology*—A. E. WALLER, Chairman; FRANCIS H. HERRICK.

## II. Reports of Officers:

The President made a brief oral report; the Secretary and Treasurer made written reports.

## III. Reports of Committees:

Under this heading written reports were submitted by the Executive Committee, the Board of Trustees, the Joint Administrative Board, Ohio Journal of Science, the Library Committee, the Committee on Co-operation with the State Department of Education, the Committee on Conservation,

the Committee on the Revision of the Constitution and By-Laws, Necrology, and Resolutions, all of which are printed elsewhere in the proceedings.

IV. *At the Banquet:*

Departing slightly from custom, the Committee on the Election of Fellows and the Nominating Committee made their reports at the conclusion of the Friday evening banquet. (Printed elsewhere.) Also voted unanimously in favor of the report of the Committee on Revision of the Constitution and By-Laws. That the report of the Nominating Committee be approved and the persons mentioned therein be declared elected.

V. *Other Motions Passed:*

1. To approve the recommendations made by the Committee on Conservation. (See report of the committee published elsewhere.)
2. To postpone action on the revised constitution from the morning business session to the evening session.
3. To approve the report of the Committee on Co-operation with the State Department of Education, and to continue the committee for another year.
4. That the Secretary, Wm. H. Alexander, be the Academy representative on the Council of the American Association for the Advancement of Science and at the Academy Conference for the 1939 meeting of these organizations at Columbus, Ohio.
5. That the vice-presidents of 1939 constitute the Nominating Committee for 1940.

VI. *Membership Campaign Approved:* "One Thousand Members by 1940."

In presenting the report of the Membership Committee, Dr. C. W. Jarvis, its chairman, spoke as follows regarding the Membership Committee and its plans for an intensive drive for new members during the ensuing year:

"All of the committee have a very definite feeling that if the program of the committee is extended and broadened, we shall have no difficulty in securing one thousand members by 1940. The members of the committee have the feeling also that the activities of the Academy might well be extended and intensified along certain lines. When a man signs a membership card, he feels very definitely that he should know where his \$2.50 is to go and what he is to receive for it. Most of us know that \$1.50 goes to pay for the *Journal*, and many scientists feel that the *Journal* should be broadened. Most sciences have other technical avenues for education; the physics people, for example, have their journals; the chemists and the mathematicians have their publications. Many lovers

of science feel that a good deal of important information regarding science, state news items, abstracts, etc., should be included in the *Ohio Journal of Science*. We hope, therefore, that those who have control of the *Journal* will widen its influence and usefulness, that it may be used as a 'talking point' in selling the Academy to prospects. We, the committee, feel very strongly that there should be some kind of junior academy of science clubs, some suitable publication for juniors in science, or at least some form of affiliation with the Ohio Academy of Science of Junior Academy Clubs. We believe something of this kind would make the Academy important to educators in high schools."

VII. *A New or Revised Constitution and By-Laws* was unanimously approved as indicated above.

VIII. *Resolutions*: See report of the Committee on Resolutions printed elsewhere in these proceedings.

Immediately following the business session on Friday morning occurred the only *General Scientific Meeting* at which three very interesting and highly informing addresses were given, namely: (1) A moving picture film was shown in connection with an address on "Hawaii, a Land of Unique Geology," by Dr. Paris B. Stockdale, of Ohio State University; (2) "Prediction of Floods in the Ohio River," by Professor Edwin L. Moseley, State Normal College; and (3) "A Naturalist's Diary," illustrated in color film, by Mr. Karl Maslowski, of the Cincinnati Museum of Natural History.

Dr. Jarvis called attention to the personnel of the committee and stated the plan of procedure in general would be for the representative of each section on the committee to appoint local representatives in the various colleges and universities over the State, possibly including many of the high schools. He closed with a plea for suggestions and hearty co-operation on the part of all members of the Academy.

On Saturday morning, under the leadership of Dr. Paul B. Sears, of Oberlin College, the University of Cincinnati sponsored a Junior Academy demonstration program entitled "*The Farm Comes to Town*." It is unfortunate that a larger number of the members of the Academy and others did not hear this decidedly unique presentation of farm conservation problems.

*The Annual Dinner* on Friday evening, followed by a short business session, was as usual the high spot of the meeting. Dr. J. Hobart Hoskins, chairman of the local committee on arrangements, acted in a most tactful way as toastmaster for



the occasion. He first introduced the President of the University of Cincinnati, Dr. Raymond Walters, who in very gracious and well-chosen words extended a most cordial welcome to the Academy and its guests; then Dr. Robert C. Gowdy welcomed the Academy in the name of the Society of Sigma Xi; then came the Presidential Address on "Taking Inventory," by President Claude E. O'Neal; Dean George F. Arps, Ohio State University, was then introduced as the *Director for the Semi-Centennial* and laid before the Academy his aims, hopes and plans for a great semi-centennial in 1940, and earnestly solicited the full co-operation of every member of the Academy in efforts to make it a worth-while celebration; on behalf of the many local societies in Cincinnati and vicinity Dr. Nevin M. Fenneman spoke words of cordial greeting. To all these words of welcome and good will, President O'Neal responded in appropriate manner.

President O'Neal then assumed the chair and a short business meeting was held at which three items of business as indicated elsewhere were transacted and the meeting adjourned.

### *Report of the Secretary*

CINCINNATI, OHIO, April 14, 1939.

#### *To the Ohio Academy of Science:*

This is our fifteenth annual report and will be about the shortest! Office routine does not require nor does it lend itself to interesting or important statement. We have had by far the largest amount of detail to look after the past year than in any of the preceding 15 years because, to be sure, we have really had more work to do, owing to the growth of the Academy and the approaching semi-centennial. Furthermore, the Secretary has been teamed-up with one of the workingest Presidents we have ever had! Properly, one's work should and in fact does speak for itself!

The constitutional duties imposed upon the office of secretary and all requests made upon the office by members and others have been taken care of promptly and, we believe, with reasonable efficiency. Fortunately, we have had ample time for the duties of the office and the fine co-operation of the entire official family has made the work very delightful. We wish here and now to record our most hearty thanks for the generous support received from every officer and member, from the President down.

Among the items over and above the purely routine may be mentioned:

1. Represented the Academy at the Richmond, Va., meeting of the A. A. A. S. and at the Academy Conference;

2. Revision and printing of the leaflet entitled "The Ohio Academy of Science," assisted by the Treasurer;

3. Revision and printing of several forms, such as the Notice of election to office, committee and membership; to Fellowship, etc.

4. Assisted in the campaign for new members—"One Thousand Members by 1940!"

5. We have fostered and encouraged as far as possible the junior academy idea and we wish to put on record here and now our firm opinion that the Ohio Academy of Science is face to face with the junior academy problem which will not "down" until properly solved. If we do not actually assist in the formation of the junior clubs we must provide some form of *affiliation*.

6. In a limited way we have encouraged legislation favorable to conservation of our natural resources, the establishment of public parks, etc.

In short, we have tried to be useful in as many ways as possible.

Respectfully submitted,

WILLIAM H. ALEXANDER,  
*Secretary.*

### *Report of the Treasurer*

#### *To the Ohio Academy of Science:*

Statement of Income and Expenses for the year ended December 31, 1938.

Cash on hand January 1, 1938.....\$ 191.96

#### CASH RECEIPTS:

##### Membership Dues—

1935.....	\$ 5.00
1936.....	30.00
1937.....	145.00
1938.....	1,081.18
1939.....	17.50

Total received from membership dues.....	\$1,278.68
Grants for Research from A. A. A. S.....	150.00
Interest on Bonds.....	39.00
Sale of Publications.....	56.86
Dinner Receipts.....	17.75
Miscellaneous Receipts.....	.52

Total Cash Receipts for the Year..... 1,542.81

Total Cash to be Accounted for.....\$1,734.77

#### CASH DISBURSEMENTS:

Speakers.....	\$ 25.00
Clerical Assistance.....	20.40
Postage and Telegraph.....	58.00
Office Supplies.....	39.04
Expense of Officers to Meetings.....	84.69

## Printing:

Proceedings in Ohio Journal of Science, 1937.....	\$191.59
Proceedings in Ohio Journal of Science, 1938.....	132.26
Other Printing Expense.....	70.75

Total Printing Expense..... 394.60

## Subscriptions:

Ohio Journal of Science, 1937.....	\$ 97.50
Ohio Journal of Science, 1938.....	555.00

Total Subscriptions..... 652.50

Research Grants.....	250.00
Secretary's Honorarium.....	100.00
Safety Deposit Box Rent.....	3.30
Reporting 1938 Meeting.....	8.60
Bond for Treasurer.....	5.00
Auditing Expense.....	15.00
Bank Charges.....	3.18

Total Cash Disbursements for the Year..... 1,659.31

Cash on hand December 31, 1938..... \$ 75.46

\$1,734.77

Respectfully submitted,

EUGENE VAN CLEEF,  
*Treasurer.*

*Report of the Auditor*

COLUMBUS, OHIO, February 23, 1939.

*To the Ohio Academy of Science:*

Pursuant to your instructions, I have audited the accounts and records of the Treasurer of the Ohio Academy of Science for the year ended December 31, 1938. These records and accounts were found to be accurately and honestly kept, and to be adequate for the purpose of controlling the financial operations, and furnishing the necessary information concerning the financial transactions of the association.

All cash receipts and disbursements for the period under review were carefully checked. The cash in bank current fund was verified by confirmation by the bank and reconciliation with the book balance. Cash in the special research fund was not verified by bank confirmation.

Members accounts receivable were certified to your auditor by the treasurer of your association.

Investment securities in the current fund were examined and found to be as stated in the records. Securities of the special research fund were not verified by examination.

I hereby certify that in my opinion the accompanying Balance Sheet sets forth fairly the financial condition of the Ohio Academy of Science as at December 31, 1938, and that the Statement of Operating Results correctly summarizes the transactions for the fiscal year ended December 31, 1938, and the changes in net worth resulting therefrom.

Very truly yours,

D. M. SHONTING,  
*Public Accountant.*

### *Report of the Trustees of the Research Fund*

#### *To the Ohio Academy of Science:*

The Trustees beg of you to report for the year 1938 the following statement of financial condition:

SUMMARY OF RECEIPTS	
Balance in Checking Account December 31, 1937.....	\$ 247.27
Received.....	73.00
Total.....	\$ 320.27
DISBURSEMENTS	
Service Charge at Bank.....	\$ .75
Balance Checking Account December 31, 1938.....	\$ 319.52
ASSETS, DECEMBER 31, 1938	
Bonds (at cost).....	\$1,300.00
Banc Ohio Stock (at cost).....	437.50
Balance Checking Account, Ohio National Bank.....	319.52
Total.....	\$2,057.02

No grant from this fund was made during the year, but the allowance from the A. A. A. S. of \$150.00 was assigned: \$100.00 to Geo. D. Hubbard, Oberlin, Ohio, for investigations on Preglacial Lake Beds in Ohio, and \$50.00 to Frank Verhoek, O. S. U., for special apparatus in research work.

Also we may state that since January 1, 1939, a grant from the A. A. A. S. of \$150.00 has been allotted to Dr. E. Lucy Braun for investigations on the major associations of the deciduous forest formation of eastern United States, and from the Academy Research fund the trustees have approved a grant of \$100.00 to Dr. G. D. Hubbard for a continuation of his studies on preglacial lake beds in Ohio. We have also other applications pending and will probably allot a considerable portion of the available balance. However, further applications will be welcome.

There is no doubt that many worthy projects could be encouraged by modest grants and it is hoped that additional research funds may become available. We would urge an effort to secure such additions by additional life memberships or donations.

In connection with the 50th anniversary in the coming year it would seem appropriate to give a historical sketch of the McMillin fund with indication of the amounts allotted for the various research projects which were assisted by grants from this fund and the subsequent additions to the Academy Research funds. The data for such a sketch is largely in hand and it would seem possible to make a fairly distinctive report that would be of interest to the Academy.

A preliminary review of the records shows that grants of near \$6,000.00 have been made to some 50 individuals to assist over sixty different projects.

Respectfully submitted,

HERBERT OSBORN, *Chairman*,  
WM. LLOYD EVANS,  
JAMES P. PORTER,

*Trustees.*

*Report of the Executive Committee**By the Secretary*

CINCINNATI, OHIO, April 14, 1939.

*To the Ohio Academy of Science:*

Your Executive Committee has held five meetings during the year with all members present at three of the meetings, all but one present at one meeting and two absent at one meeting—probably a record for committee meetings! Certainly an indication of the aggressive, energetic administration put on by our active, ambitious President!

The major items of business above were routine in importance transacted at these meetings may be mentioned the following:

1. The approval of 57 applications for membership, all of which have been passed on to the Membership Committee for inspection and recommendation.

2. The Treasurer was authorized to drop all members of the Academy who are more than two years in arrears with their dues, after final notice.

3. The appointment of a Director, Dean George F. Arps, as Director of the semi-centennial and the appointment of the ten committees provided for in the preliminary plans of the celebration.

4. The selection of the place and the fixing of the date of the annual meeting for 1939.

5. Considered in detail the preliminary report of the Committee on the Revision of the Constitution and By-Laws.

6. Considered a preliminary report by the committee appointed to co-operate with the State Director of Education relative to the proper training of teachers of science in the junior and senior high schools of the State.

7. The Treasurer was authorized and requested to confer with Joint Administrative Board and see what, if anything, could be done toward a readjustment of the financial arrangements now existing between the Academy and the Board, and failing this to confer with the Ohio State University authorities in the hope of securing an increased allowance from that institution.

8. The tentative date of May 9, 10 and 11, 1940, was fixed for the Semi-Centennial.

9. Approval was given to an intensive membership campaign and the slogan suggested by the Secretary, "One Thousand Members by 1940," was adopted.

10. Unanimously approved the recommendations of the Committee on Conservation.

*Report of Membership Committee*

CINCINNATI, OHIO, April 14, 1939.

*To the Ohio Academy of Science:*

The following applications for membership in the Academy, accompanied by one year's dues, have been received during the year, approved by the Executive or Membership Committee, or both, and are now recommended for final approval by the Academy, viz.:

- AVERY, WILLIS F. (F), The B. F. Goodrich Co., Akron.  
 BERGER, BENJAMIN, (D), 133 W. Ninth Ave., Columbus.  
 BILLS, ARTHUR G., (E), 3423 Whitfield Ave., Cincinnati.  
 BRAND, LOUIS, (I), 2603 University Court, Cincinnati.  
 BRIEF, B. J., (D), 769 Kimball Place, Columbus.  
 BUNCH, ROSELLA, (C), 186 W. College St., Oberlin.  
 BURGESS, WAYLAND M., (H), University of Cincinnati, Cincinnati.  
 CHANDLER, DAVID C., (A), Stone Laboratory, Put-in-Bay.  
 CHILDRESS, NORMAN F. (B and H), Ohio State University, Columbus.  
 CLARK, PAUL ENOCH, (H, I and F), New Concord.  
 COGHILL, G. E., (A), R. F. D. No. 2, Box 77A, Gainesville, Fla.  
 COLE, LAWRENCE E., (E), 111 S. Cedar, Oberlin.  
 COLES, VICTOR, (A and B), 2910 Grasselli Ave., Cincinnati.  
 CONSOLATA, SISTER MARY, (H), 2234 Overlook Road, Cleveland.  
 COTTERMAN, CHAS. W., (A), B. & Z. Bldg., O. S. U., Columbus.  
 CUNNINGHAM, JOHN F., (A and B), Townshend Hall, O. S. U., Columbus.  
 DAMBACH, CHARLES A., (A and B), 1902 Auburn Ave., Dayton.  
 DEAROFF, KENNETH, (B), Public Library Museum, Dayton.  
 DOAN, KENNETH H., (A), Stone Laboratory, Put-in-Bay.  
 DUNLAP, H. L., (H), 275 E. State St., Athens.  
 FIDDLER, MRS. CLARICE McADOW, (A and B), Hotel Hester, Manchester.  
 FIELDS, PAUL E., (E), 138 N. Sandusky St., Delaware.  
 FRONIS, ARTHUR GEORGE, (H, F and E), 785 New Garden Ave., Salem.  
 GARRETT, ALFRED B., (H), 205 W. Henderson Rd., Columbus.  
 GIBBONS, CHARLES C., (E), 115 Sixteenth Ave., Columbus.  
 GIER, HERSCHEL T., (A), Ohio University, Athens.  
 GOLDBERG, LAWRENCE, (D), 38 W. Washington, Athens.  
 HANSEN, HUGH GROVES, (G), 76 E. College St., Oberlin.  
 HODGMAN, CHARLES D., (F), Case School of Applied Science, Cleveland.  
 HODGMAN, MARGARET E., (B), 2119 Marlindale Rd., Cleveland Heights.  
 HOUSEHOLDER, FRED F., (F), 1209 Berwin St., Akron.  
 HUGHES, JOHN H., (A), 81 South St., Jackson.  
 IRELAND, HUBERT ANDREW, (C), Soil Conservation Service, 447 N. Broadway, New Philadelphia.  
 KELLY, HENRY A., (C, A, H and F), 316 W. Washington St., Howell, Mich.  
 KNAUSS, HAROLD P., (F), Mendenhall Laboratory, O. S. U., Columbus.  
 LANDE, ALFRED, (F), Mendenhall Laboratory, O. S. U., Columbus.  
 LEWIS, ROBERT DONALD, (B), Department of Agronomy, O. S. U., Columbus.  
 MARTIN, GEORGE C., JR., (C), 46 W. Tenth Ave., Columbus.  
 MOLZ, FRANCIS J., (A and B), University of Dayton, Dayton.  
 MOULTHROP, PHILIP N., (A), 2717 Euclid Ave., Cleveland.  
 NELSON, R. H., (A), 151 W. Eleventh Ave., Columbus.  
 NOVY, WILLIAM S., (A), 41½ W. Washington, Athens.  
 OSGOOD, THOMAS H., (F), University of Toledo, Toledo.  
 POPHAM, RICHARD A., (B), Botany Department, O. S. U., Columbus.  
 POOL, M. L., (F), Ohio State University, Columbus.  
 PORTER, LAWRENCE HAROLD, (B), B. & Z. Bldg., O. S. U., Columbus.  
 PORTER, T. WAYNE, (A), 327 W. Water St., Oak Harbor.  
 PRATHER, W. D., (H and A), 408 Broadway, Aurora, Ind.  
 PYLE, W. R., (F), 240 Fife St., Wilmington.  
 QUIRING, DANIEL P., (A and B), Western Reserve University, Cleveland.

REYNOLDS, RALPH J., (B and A), 2645 Powell Ave., Columbus.  
RICH, JOHN L., (C), University of Cincinnati, Cincinnati.  
RING, GORDON C., (D), Hamilton Hall, O. S. U., Columbus.  
ROCKWOOD, RUTH C., (G), R. F. D. No. 1, La Grange.  
SHANKLAND, ROBERT S., (F), Case School of Applied Science, Cleveland.  
SHARPE, C. F. STEWART, (C and G), 337 Ashwood Lane, N. W., New Philadelphia.  
SIEKERES, ALBERT, (A and F), Kipton, Ohio.  
SMITH, RUTH ELIZABETH, (C), 109 Lakeside, New Concord.  
SNODDY, A. O., (H), R. F. D. No. 6, Cincinnati.  
SPERTI, GEORGE SPERI, (Scientific Research and Education), 6616 Beechmont Ave., Cincinnati.  
STOLTZ, ROBERT B., (Dairy Mfg.), 1971 Concord Rd., Columbus.  
STUMM, ERWIN O., (C), Oberlin.  
SUMNER, CHARLES B., (A, B and D), Kent State University, Kent.  
THORNTON, C. S., (A and B), Kenyon College, Gambier.  
UNNEWEHR, E. C., (F), 109 Seminary St., Berea.  
VAUGHN, JAMES, (E), 413 McAlpin, Cincinnati.  
VON DACH, HERMAN, (A), B. & Z. Bldg., O. S. U., Columbus.  
WILLIAMSON, C. O., (I), College of Wooster, Wooster.

Respectfully submitted,

C. W. JARVIS,  
*Chairman.*

*Report of the Joint Administrative Board  
of the Ohio Journal of Science*

CINCINNATI, OHIO, April 14, 1939.

*To the Ohio Academy of Science:*

The only meeting of the Joint Administrative Board of the Ohio Journal of Science since the last report was held at the Ohio State University, April 1, 1939. Present were all members of the board, the editor and the business manager. The meeting was called to order by Chairman Rice at about 1:00 P. M. The minutes of the preceding meeting were read and approved.

Upon motion, the terms of all present officers were continued for the year 1939.

Motion carried that the Journal carry an article dealing with the services of the late Prof. J. H. Schaffner as past editor of the Journal. Motion carried that the Joint Administrative Board recommend to the Ohio Academy of Science that the proceedings of the 50th anniversary meeting of the Ohio Academy of Science, whatever its format, be issued as part of the regular publication series of the Ohio Journal of Science. It was agreed that the recommendation would not be formally presented to the Academy without the prior approval of Dean Arps. Dr. Transeau agreed to discuss this matter with Dean Arps.

The business manager of the Journal tendered his formal resignation of this position, to be effective at the end of the present fiscal year.

The business manager presented his financial report for the fiscal year 1938 as follows:

## RECEIPTS

Balance from 1937.....	\$ 437.20
From Ohio State University.....	750.00
Ohio Academy of Science—Dues.....	640.50
Ohio Academy of Science—Publication of Proceedings.....	132.26
Subscriptions.....	74.94
Author's Payments for Plates.....	92.46
Sale of Back Numbers.....	38.50

---

\$2,165.86

## EXPENDITURES

Spahr and Glenn Co., Printing Vol. 37, No. 6.....	\$ 497.17
Spahr and Glenn Co., Printing Vol. 38.....	1,331.71
Postmaster, Columbus, Ohio.....	108.00
Bucher Engraving Co.....	201.14
Clerical Assistance.....	6.50

---

\$2,144.52

Balance on Hand, January 27, 1939.....	21.34
(Huntington National Bank)	

---

\$2,165.86

As of this date one bill to the Bucher Engraving Co., in the amount of \$39.56, was unpaid. All other 1938 bills are paid.

Upon motion this report was accepted and placed on file, Dr. Transeau being appointed a committee of one to audit the business manager's report.

The meeting adjourned at about 2:00 P. M.

Respectfully submitted,

B. S. MEYER,

*Secretary of the Board.*

### *Report of the Library Committee*

COLUMBUS, OHIO, April 11, 1939.

#### *To the Ohio Academy of Science:*

Much of the routine work of the chairman of this committee has consisted in taking care of the mailing list and in supplying numbers of the Ohio Journal of Science when requested.

Late in the year the exchanges were checked in the Ohio State University Library and only a few were found to be inactive. Some of them sent their publications in response to letters which were written to them and the others were dropped from the mailing list. Five new exchanges were added, making a total of 361, of which 97 are in this country and 264 in foreign countries. As some of them send more than one publication we are now receiving nearly 560 different titles. A few publications also come as gifts. A complete list of the exchanges was typed onto sheets and distributed to the members of the library committee and to several others.

The sales of publications amounted to \$25.15. The largest single order was for fourteen copies of Dr. W. G. Stover's Agaricaceae of Ohio and was placed by the Botany Department of Ohio University.



Thirty-seven copies of ten Special Papers were sold in eighteen sales. Only two sales were made to persons living outside of our own State. The sum of \$57.38 has been given to the Treasurer. This included \$32.25 which was withdrawn from the building and loan company when the account of the Academy was closed at the beginning of the year. This fact was mentioned in last year's report, but it is stated again this year as it appears in the financial report which is appended to this report but not included in it. A copy is on file for the purpose of record in the office of the Treasurer and also in the library of the chairman of this committee.

Respectfully submitted,  
ETHEL MELSHEIMER MILLER,  
*Chairman.*

*Report of Committee to Co-operate with Ohio Department  
of Education*

CINCINNATI, OHIO, April 14, 1939.

*To the Ohio Academy of Science:*

The Committee appointed by the President pursuant to a resolution passed by the Ohio Academy of Science at the annual meeting one year ago to co-operate with the Ohio Department of Education in outlining the proper requirements in preparing teachers of science for the Ohio junior and senior high schools, submits the following and recommends its approval by the Academy, viz.:

1. All applicants for certification as teachers of science in the junior and senior high schools under the laws of Ohio shall be required to present as a *minimum preparation* 40 semester hours in science, consisting of 24 semester hours distributed as follows: 6 semester hours in Botany, 6 semester hours in Zoology, 6 semester hours in Chemistry, 6 semester hours in Physics, or their equivalent as defined by the several institutions of higher education in Ohio, and 16 further hours elected from the above subjects, or from Astronomy and Geology.

2. (a) A student seeking the Master's degree in order to qualify under the proposed Ohio requirements may complete these degree requirements in the field of science rather than in a specific department;
- (b) Or in Physical Science and Biological Science.
- (c) Or a major in Physical Science and a minor in Biological Science, or vice versa;
- (d) Or a major in a department.

Respectfully.

C. G. SHATZER, *Chairman*,  
W. A. MANUEL,  
H. C. SAMPSON,  
A. W. LINDSEY.

Recommendation unanimously approved by the Academy, April 14, 1939.—W. H. ALEXANDER, *Secretary*.

*Report of the Committee on Conservation*

CINCINNATI, OHIO, April 13, 1939.

*To the Ohio Academy of Science:*

Your Committee on Conservation begs to submit the following report of conservation activities in Ohio during the past year.

*Division of Conservation*—An important milestone in the annals of Ohio conservation was passed, it is believed, when the Ohio legislature enacted Senate Bill No. 165, which is designed to remove conservation matters from politics. Briefly, the bill provides that the Commissioner of Conservation and not more than two Assistant Commissioners be appointed by the Conservation Commission, instead of by the Director of Agriculture, as heretofore; and the terms of the members of the Commission are increased to eight years, in order to lessen the likelihood of any given political administration gaining control over the Commission. The name of the division is made to include natural resources: the Division of Conservation and Natural Resources. The Commission controls matters of policy and program and the Commissioner has charge of personnel.

A brief review of the history of official conservation activity has been provided by Mr. E. L. Wickliff:

In 1873 the Ohio legislature passed a bill providing for the appointment of three Fish Commissioners. The commissioners were appointed in 1875, marking the beginning of our present Division of Conservation and Natural Resources. It will be noted that the Fish Commission devoted all its activities to fish and that game was not at this early stage of development deemed to require attention. Among other duties of the Fish Commission were: "To examine the various rivers, lakes, ponds and streams of the state of Ohio—with a view of ascertaining where they can be rendered more productive of fish and what measures are desirable to effect this object, either in restoring the production of fish in them or in protecting or propagating the fish that at present frequent them . . . ." It will thus be seen that the duties of the Fish Commissioners were much the same as they are today and that even in those days they talked about depletion and the restoration of the depleted fish supply, just as we do today.

In 1886 the legislature provided for a Fish and Game Commission of five members, adding the protection of game to their duties. In 1913, the Division of Fish and Game was placed under the State Department of Agriculture. In 1923, an Advisory Board was appointed. In 1929 the legislature changed the name of the Division of Fish and Game to the Division of Conservation.

*Soil Conservation*—In Ohio at the present time there are 5 Erosion Control Demonstration projects and 11 CCC camp work areas. The project areas which cover rather intensively all or a part of the drainage basin or watershed of a stream are located near Wooster, Mt. Vernon, Zanesville, Hamilton, and Cambridge. The work areas of these five projects touch 10 counties.

Each CCC camp work area usually includes a number of farms in one county, and usually extends to one tier of townships in the adjoining counties. The present camps are located near Bellefontaine, Eaton, Lebanon, Wilmington, Peebles, Chillicothe, Lancaster, Mt. Vernon, Carrollton, Shreve and Zanesville.

The number of farms for which complete conservation plans have been developed total approximately 2,700. This is about 1 percent of the farms of the state and  $1\frac{1}{2}$  percent of the land in farms. These demonstrations are distributed in about 60 of the 88 counties. The following table shows the change in land use on 331,311 operating under a co-operative agreement with the Soil Conservation Service.

	Before Planning %	After Planning %
Crop Land.....	54.5	43.2
Permanent Pasture.....	29.0	30.0
Permanent Hay.....	0.9	5.4
Woodland.....	4.1	15.4
Miscellaneous.....	11.5	6.0

On these farms on 147,446 acres of crop land the percentage distribution of erosion control practices is as follows:

Contour Tilled.....	52.2 percent
Strip Cropped.....	26.1 "
Terraced.....	2.2 "
Combination of Terracing and Strip Cropping.....	0.5 "

It is very evident that contour tillage and strip cropping are the most common erosion control practices in Ohio.

*Sealing of Abandoned Mines*—Report from Mr. F. H. Waring, Chief of the Division of Engineering of the Ohio Department of Health for 1938, covers the accomplishment for that year and for the last five years. Abandoned mines have been sealed in 25 counties along the Ohio River from Mahoning on the north to Scioto on the south and as far inland as Coshocton County. Funds for this work have been provided by the Federal Government through CWA, ERA, and WPA.

As of December 31, 1938, a total expenditure of \$1,929,337.02 of federal funds had been made for this work, and the following accomplished in the five-year period: Openings closed, 57,426; water samples collected, 12,446; labor costs, \$1,769,798.11; material costs, \$53,218.05; supervisory cost, \$106,320.86; cost per opening closed, \$33.60; counties worked, 25; mines sealed, 3,468; per cent acid reduction 64.7 (based on a study of 1,301 mines to July 1, 1938); average acid per mine in tons per year, 58.7 (based on a study of 1,671 mines to July 1, 1938); average cost per mine, \$518; average number of openings per mine, 14.6; and cost per ton acid, \$8.86. Of the total cost, 91.8 per cent was expended for labor, 2.7 for materials, and 5.5 for supervision.

During the year 1938, a federal expenditure of \$904,782.76 was made in sealing 29,895 mine openings in 2,043 mines in 25 counties, with a labor cost of 94.8 per cent, materials 2.9 per cent, and supervision 2.3 per cent. The average cost of sealing openings was \$30.27.

The original acid contained in the drainage from 1,301 mines studied was 74,495.47 tons per year; at the last sampling, in the second quarter of 1938, it had been reduced to 26,288.42 tons per year. The average cost of sealing each of these mines was \$469.84. On July 1, 1938, records on 1,671 sealed mines showed they contained 24,446 openings (an average of 14.6 each), the original acid content of the drainage was 98,010.90 tons per year, and the average acidity was 58.7 tons per year.

Employment during 1938 varied from 1,849 men in May to 995 in December. All abandoned mines were sealed in 15 counties where permission could be obtained from the surface owners and the mining-rights owners to do so. This included by far the greater part of the abandoned mines in these counties. Active work is still being carried on in 10 counties.

On July 1, 1938, the supervisory staff of 14 persons employed by the U. S. Public Health Service and paid with WPA funds was discontinued and since that date only one part-time engineer from the State Health Department has given supervision to the project.

A new project was submitted to the Federal Government for approval in the latter part of 1938 for a total expenditure of \$484,160, of which \$448,592 represented federal funds. This project was to cover 15,150 mine openings, with the greater part of the work to be done in counties in which work has not been completed.

However, it is contemplated that considerable maintenance work will be necessary in the other counties in order to repair the seals of openings already closed, and to close any openings which have developed since the sealing was done.

The Department of Health provided exhibits of this work at Cincinnati Sportsmen's Show and the Toledo Sportsmen's Show. Likewise, considerable publicity has been given to the benefits of mine sealing projects through use of the public press. The work is in charge of Engineer B. F. Hatch, of the Department.

*Department of Forestry*—For financial reasons the program of the Division of Forestry during the past year has not been greatly expanded.

However, it was possible to place a man on public relations work. Although the appointment was not made until October, the effects of this work are already being appreciated.

Recreational use of the state forests and forest parks continues to increase. This reflects an increased drain on maintenance funds which have not been adequate to meet the situation. During the year just ahead the Division will be expected to employ any help necessary to plan CCC projects and maintain all completed work. Failure to meet this obligation will lead to the loss of some, if not all, of the camps now operating on the state forests.

The area of forests receiving organized forest fire protection remains at 1,000,000 acres with another million acres in need of protection which cannot now be provided.

Three land utilization projects totaling more than 35,000 acres will be turned over to the Division early in 1939. On each project

are extensive recreational developments, the successful operation of which will require additional personnel.

The Division of Forestry has assumed sponsorship for a WPA project having as its threefold objective the survey of farm woods in 21 counties in Ohio, a survey of the forest plantations in the State and the eradication of *Ribes* in those sections of Ohio where white pine is, or may be, of economic importance. This project which is under the direct supervision of trained foresters is expected to yield a great deal of very valuable information.

*Ohio Wildlife Research Station*—Of the 19 projects of the Ohio Wildlife Research Station, two are new and five were completed during the last year. The number of persons engaged in whole or part time work related to wildlife research of the Station during 1938-39, was 24. Twelve reports have been published, 26 mimeographs issued, and 42 manuscript progress reports filed. Present projects involve areas in 72 of the 88 counties of the State.

Pheasant refuge and controlled hunting management techniques developed in Wood County are rapidly being put into operation elsewhere in Ohio and, to a lesser extent, in several other States. A series of reports based on the Wood County studies are now available, which involve critical explorations in the fields of wildlife-agricultural land-use, game economics, game yields in relation to management and land-use, controlled hunting and farmer-sportsmen relationships. As a result of these reports, the exact factors involved in producing sustained annual pheasant crops are probably better known for Wood County than for any other in the United States.

Studies have continued in the development of techniques for conditioning breeding stock of pheasants, raccoon, rabbits and other species to increase their "stocking value." A recent report summarized the record of more than 10,000 surplus naturally produced wild pheasants which were live-trapped on three Wood County refuges. Banding returns and population studies indicate that birds so obtained have a stocking value far superior to that of birds produced on game farms. This research points the way to a day not far distant when game farms with their artificial propagation will be abolished, releasing man-power and money for practical development of natural habitats in accordance with sound ecological land-use principles. The development of techniques for producing in the wild surpluses of superior native brood stocks, will eliminate, for example, the inexcusable importation of western rabbits and the tularemia and Rocky Mountain fever which comes along with them.

A monographic study of the Fox Squirrel nears completion. This includes many critical ecological land-use studies of Ohio woodlots and population data on more than a thousand animals trapped and tagged. Similar studies have been made of 900 live-trapped rabbits. A survey of Ohio squirrel diseases has been completed and is now being prepared for publication. Two other long-time projects concern (a) a statistical and ecological analysis of the raccoon populations of two central Ohio counties, and (b) disease, nutrition, reproduction and conditioning studies of 2,200 captive raccoon at the Milan farms.

A ten-year survey of population fluctuations of the Hungarian Partridge is nearing completion. At Pymatuning Lake more than 1,000 waterfowl have been banded to study the origin and dispersal of a newly created waterfowl population located on the divide between the great Atlantic and Mississippi flyways.

The conservation education program of the Ohio Wildlife Research Station grows each year. During the last twelve months the staff has given 42 lectures and radio talks, held conferences with 251 visitors (many from outside Ohio) on problems of the wildlife profession, given advanced undergraduate or graduate training and instruction to 18 students, given technical assistance on 148 wildlife conservation problems in Ohio, arranged five extensive wildlife management exhibits, participated in youth education, 4-H Club and camp work, and distributed more than 210,000 pages of reports on Ohio conservation research.

*Southern Ohio Wildlife Sanctuary and Demonstration Project*—The wildlife sanctuary and research project sponsored and encouraged by the Ohio Academy of Science in Southern Ohio now enters its fifth year. During the first four years, fourteen sanctuaries and refuges were established on the Roosevelt Game Preserve, and the Shawnee, Scioto Trail, and Pike County State Forests. Major research studies involving wildlife land-use; forestry-wildlife relationships; wildlife harvest methods; life history, ecology, and management of the White-tailed Deer, Ruffed Grouse, and Gray Squirrel; and surveys of the wildlife food, cover, and water resources were brought to a close in September, 1938, when the investigator, Floyd B. Chapman, was awarded a Doctor's degree in Wildlife Conservation at the Ohio State University. The subject of the dissertation was "The Development and Utilization of the Wildlife Resources of Unglaciaded Ohio." Bound copies of this 800 page report are on file in the Ohio State University Library, the Ohio Division of Conservation, the U. S. Biological Survey, and the Ohio Wildlife Research Unit. Two sections of the dissertation have been published by the American Wildlife Institute, namely: "Summary of the Ohio Gray Squirrel Investigation" and "The White-tailed Deer and its Management in Southeastern Ohio."

In 1939 it is planned to enlarge the sanctuary program to include other State Forest areas and the Wayne National Forest. At present three sanctuaries are being placed in the Ross-Hocking State Forest, and it is planned to establish three areas in the Zaleski State Forest, Vinton County, in the near future. One or more refuges will be set aside in the Vesuvius section of the Wayne Forest in Lawrence County, and in Muskingum County, three refuges are being established in the Muskingum Resettlement project. Dr. Chapman has been placed in charge of all wildlife management work on public lands in Southern Ohio, with headquarters at Chillicothe. The major objective during the next few years will be to put into effect the wildlife management and other recommendations incorporated in the preliminary research report.

## RECOMMENDATIONS

(1) Inasmuch as the Geological Survey of Ohio is of fundamental importance respecting our knowledge not only of the mineral resources of Ohio, but also of our biological resources, that adequate appropriation of funds be allowed for the continuance of the work.

(2) Your committee recognizes the fundamental importance of the soil survey in the program of land-use planning and soil conservation and urges that adequate funds be provided for the completion of these surveys.

(3) Your committee recommends that the Division of Conservation and Natural Resources and the State Department of Education co-operate in a program for the teaching of the principles of Conservation in the public schools of the state.

(4) Your Committee recommends that the Academy request the Legislature now in session to adopt such legislation as will effectively create a co-ordinating board made up of directors of the various State departments interested in conservation, forestry and recreational activities for the State: Such board also to make a complete survey of the natural resources of the State for the purpose of formulating a policy and program for administering the use of our natural resources.

(5) Recognizing the benefits to our streams from the sealing of abandoned coal mines in the reduced amount of acid draining into them, your committee urges that an adequate annual appropriation be made for the maintenance of openings already closed and the sealing of recently abandoned mines.

(6) Your committee recommends an investigation as to the relation between the importation of western rabbits and the apparent increase of tularemia and Rocky Mountain spotted fever in Ohio.

(7) Your committee urges the acquisition by the state for purposes of conservation and recreation of natural areas threatened with destruction, and specifically recommends the following: (1) A series of state parks on Lake Erie, (2) The Oak Openings west of Toledo, (3) Fern Lake in Geauga County, (4) Additional areas at Fort Hill, Highland County, (5) The Beaver Creek region in Columbiana County, (6) Rock Run in Jackson County, and (7) Cedar Swamp in Champaign County.

(8) Convinced of the soundness of the recommendations of this committee in former years, your committee reaffirms and urges the adoption of the same.

Respectfully submitted,

EMERY R. HAYHURST,	EDWARD S. THOMAS, <i>Chairman</i> ,
EDMUND SECREST,	W. E. STOUT,
L. E. HICKS,	G. W. CONREY,
F. H. KRECKER,	E. L. WICKLIFF,
	ROBERT B. GORDON.

*Report of Committee on Election of Fellows*

CINCINNATI, OHIO, April 14, 1939.

*To the Ohio Academy of Science:*

The Committee on the Election of Fellows met last evening at Hotel Gibson, Cincinnati, Ohio, with all members present except two, the President of the Academy presiding. All nominations to fellowship then on file were carefully considered by the committee and the following members received the required three-fourths vote of the committee and were therefore declared elected to Fellowship in the Ohio Academy of Science, viz.:

DR. AMOS C. ANDERSON.....	Ohio University
DR. ROLLO CLYDE BAKER.....	Ohio State University
DR. CECIL ERNEST BOORD.....	Ohio State University
DR. LOUIS BRAND.....	University of Cincinnati
DR. JOHN BERNIS BROWN.....	Ohio State University
DR. GEORGE M. CURTIS.....	Ohio State University
DR. CHARLES AUSTIN DOAN.....	Ohio State University
DR. BRUCE C. FREEMAN.....	Ohio State University
DR. NOEL PAUL HUDSON.....	Ohio State University
DR. HAROLD JOHN KERSTEN.....	University of Cincinnati
DR. PAUL CLIFFORD KITCHIN.....	Ohio State University
DR. CARL A. LAMEY.....	Ohio State University
DR. LAWRENCE L. QUILL.....	Ohio State University
DR. FRANCIS E. RAY.....	University of Cincinnati
DR. JOHN LYON RICH.....	University of Cincinnati
DR. PAUL BIGELOW SEARS.....	Oberlin College
DR. LEON E. SMITH.....	Denison University
DR. JOHN AUGUSTUS TOOMEY.....	Western Reserve University

Respectfully submitted,

WILLIAM H. ALEXANDER,  
*Secretary.*

*Report of Committee on Necrology*

CINCINNATI, OHIO, April 15, 1939.

*To the Ohio Academy of Science:*

Notice of the death of but two members of the Academy during the year has come to the attention of your committee, both very distinguished in their chosen fields and highly honored not only among the members of this Academy but by scientists generally, namely, Dr. John H. Schaffner and Dr. Samuel Prentiss Baldwin. A brief outline of the life and work of each follows:

## SAMUEL PRENTISS BALDWIN

FRANCIS H. HERRICK

Samuel Prentiss Baldwin, widely known for his pioneer work in trapping and banding wild birds and for his Research Bird Laboratory, was born at Cleveland, Ohio, on October 26, 1868, and died of coronary



thrombosis in that city on December 31, 1938. He was the son of Charles Candee and Sophia (Prentiss) Baldwin.

His father, a judge of the circuit court of appeals, was one of the founders and principal supporters of the Western Reserve Historical Society and was deeply interested in archaeology and geology. The son was a trustee of the Historical Society from 1907 until the end of his life.

Graduating from Dartmouth College in 1892, and from the Law School of Western Reserve University in 1894, Prentiss Baldwin withdrew from the practice of law in Cleveland in 1900, and for a number of years was engaged in business. After some field work in geology, he returned to his first love, natural history, and devoted himself more or less completely to ornithology.

In 1914 Mr. Baldwin became interested in the newly devised method of banding wild birds—encircling one of their legs with a numbered, aluminum ring or band—so that, if later recovered and reported, incontrovertible data upon their wanderings and longevity could be secured. In the course of these practices, which were systematically conducted in summer at "Hillcrest Farm," the Gates Mills property of Mr. and Mrs. Baldwin, in Ohio, and at Thomasville, Ga., in winter, he devised traps for securing large numbers of living birds, and originated the method of trapping-and-banding adult birds, which by 1920 had become so successful that it was approved by the Biological Survey. This governmental agency, which took over the work of the American Bird-Banding Society in 1920, soon became the "clearing house" for the registration of the recovered and reported aluminum bands that began to flow in from all parts of the country. As a result of this movement four Bird-Banding Associations, the Inland, Eastern, Northeastern and Western, were established. It is estimated that Dr. Baldwin, who became the honorary president of all of these organizations, and his assistants alone have banded between 50,000 and 60,000 individuals.

Since 1914 Prentiss Baldwin was devoted to the intensive study of ornithology at what became known as "The Baldwin Bird Research Laboratory" at the "Hillcrest Farm," from which have issued upwards of thirty more or less elaborate papers or treatises, relating to the physiology, development and life-history of birds, based upon his own work and that of his associates.

Dr. Baldwin soon fixed upon the little house wren as the one species that was best suited for the study of many avian problems, touching distribution, migration, anatomy, physiology, development and behavior. In short this wren, through studies at the Baldwin Laboratory, became in some measure for ornithology what the diminutive fruit-fly, *Drosophila*, is for the science of heredity or genetics. The wren, like *Drosophila*, is easily handled and controlled; it nests readily in artificial boxes, wherever placed, and can be trapped in its nest-box and quickly caught in a hand-net for examination. If it does not submit placently to interference, it seldom or never deserts its young.

Through the testimony of the numbered bands it was shown that house wrens do not mate for life, but that on the contrary they often

change mates between seasons, and even between broods of the same year. It was also proved that not more than one-third of all marked individuals return to their nests, or to the locality in which their young were hatched, in two successive years.

Many ingenious electrical recording devices, originating in the Baldwin Laboratory, were used in determining the bodily temperature changes, which the growing young undergo from an early egg-stage to adolescence, and in recording visits of the parent birds to their nest when tending their young. Experimenters in this laboratory also perfected an instrument for taking motion pictures of the developing living embryo *in ovo*.

Dr. Baldwin was a trustee of the Cleveland Museum of Natural History for nearly sixteen years, or from 1923 until his death, and in many ways gave it his generous support. He received the degree of D.Sc. from Dartmouth College in 1932, was a fellow in the American Association for the Advancement of Science, the Geological Society of America, the American Ornithologists' Union and the Ohio Academy of Science, and a member of the American Society of Naturalists, the American Society of Zoologists, the British Ornithologists' Union, Deutsche Ornithologische Gesellschaft and the Australasian Ornithological Union.

Through his efforts and those of his assistants, Dr. Baldwin had gathered a remarkably rich store of scientific data upon birdlife, represented chiefly by the house wren, which, if properly edited should make an outstanding monograph. It is to be hoped that this work, for which he had labored so industriously, but which unfortunately he did not live to complete himself, may yet be given to the world.

Dr. Baldwin was married on February 15, 1898, to Miss Lilian Converse, daughter of Leonard Hanna, of Cleveland.

In his personal relations Prentiss Baldwin will be remembered as a loyal friend, who was ever ready to extend a helping hand, especially to young men who were devoted to science. He took a broad view of his opportunities, and freely gave his time, his effort and his means for the protection and preservation of the wild life of the countryside. The many friends of Dr. and Mrs. Baldwin, and particularly the members of Western Reserve University, of which he was a research associate in biology, can never forget the generous hospitality which they have enjoyed in their beautiful home.

---

#### PROFESSOR SCHAFFNER

ADOLPH WALLER

With the passing of Professor Schaffner, there is defined for botanical sciences another landmark of a period now gone. We are tempted to think of these devoted members as giants because of the work accomplished extending into many fields. No young man today in an era of restricted research would possess the temerity to grasp, or the courage to look forward to solving new problems in so many divergent lines as seemed familiar to the older generation. The answer, of course, is that each individual was his own research center. In the forty or

fifty year span that marks the active period of these men from a single individual has sprung a whole department of workers, from a single pioneer paper has emerged an entire field of scientific work not previously perceived. It has been this proliferating process that extends the fields covered by one worker. For as he built solidly, each operation became a base for others. While Professor Schaffner is not alone in living through this period of expansion, there are few who have led the procession to the various inauguration scenes more determinedly. Here was a man whose observations of minutiae were guided into formulating original and basic principles. His faith in his own endeavors never flagged. His critical judgment directed him to separate false and true leads unhesitatingly. There are several marked instances of this. In the period when cytology occupied Professor Schaffner's early activities the work on the chromosome and its significance was in its infancy. His contributions in this field along with other botanists and zoologists have laid the firm foundation for the chromosome theory and its relation to Mendelism.

The controversy on the inheritance of sex was treated in a most unbiased manner. At the beginning of Mendelian expansion no one thought of sex inheritance. Then came the X Y type of inheritance in *Drosophila*. The suggestions offered do not fit the plant kingdom for most types. Nor is the suggestion of hermaphroditism at all the same as the situation in a heterosporous sporophyte. Schaffner began carefully defining primary and secondary sexual states. He followed this with a straightforward explanation of the difference between factors and their expression. Then began a patient exploration of the nature of sex and the time of its determination in the plant types. A series of experiments and deeply philosophical questionings led to a long series of papers over a period from 1910 to 1937. These may be grouped into three fields: (1) the nature and determination of sex, (2) sex control and sex reversal, (3) rejuvenation. A total of thirty-eight papers in these three fields appeared during the twenty-seven years. Moreover, they opened the way for other workers to see sexuality in a vastly different light and saved many workers the mistake of reasoning by analogy to a false conclusion. As is the only method for extending sure knowledge, an idea represented not a finished accomplishment, but a tool for testing facts and redistributing them.

Teaching beginning students was never the right medium for the effective use of Professor Schaffner's talents. He was likely to be so intent on the problems of the plant as to convey the impression of a wholly disinterested and impersonal attitude toward the class. All topics were of interest to him. Beginning students were unable to grasp the magnitude of the problems spread out before them or to appreciate the amazing accuracy of a difficult vocabulary. It was just the reverse with the advanced students. Each word fitted into its proper meaning with the beautiful logic and precision of the cut facets of a gem. I remember from my own student days that each lecture was a startling revelation of a process that was new to me. It was a process of seeing a person think—not a formalized lecture. Even though his lectures were difficult for beginners, his methods of teaching

were advanced for his day. The diagrams of life cycles have been copied over again and again in many textbooks. His keys to woody plants have never been surpassed in simplicity and directness. In the same fashion, his approach to the understanding of the plant kingdom through a structural taxonomy will be in use for a long time. It was with the keenest delight that he found the confirmation for his classification principles coming from the vastly different approach made by Mez and his co-workers. And I shall never forget having seen the joy with which Mez greeted Schaffner at one of the international botanical congresses, where, after years of correspondence, they met for the first time.

It was the peculiar fate of Professor Schaffner to be highly regarded by the elect among his colleagues, both at home and abroad, but to be unknown to the majority of students on the campus. I doubt if one out of a hundred undergraduates either knew or saw him or was aware of his importance in the study of plants. He was most approachable and genial when sought, but was rarely known to seek diversion or entertainment among his colleagues. Instead, they came to him with questions and always found him ready. He had worked out the answers alone.

Somewhere Mark Hopkins is credited with the thought that the measure of happiness in life is a delicate balance between what one is and what one has. From Professor Schaffner's beginnings as a farm boy on the Kansas prairie with a hard-won battle for education, in which the classics were strongly featured and the religious influence profound, to a great leader in expanding modern botanical science seems a great step. It could not have been achieved by any means but the increasing employment of his talents. And in his long productive career the delicacy of the balance between what one is and what one has was never disturbed. He worked tirelessly because it was in his work he found his greatest happiness.

Our graduate students who enjoyed the opportunity of studying with Professor Schaffner are in agreement that his patient, everlastingly patient, attempt to give to them the insights he possessed into the structures and development of plants is for them a constant inspiration. A single specimen, often hastily glanced at, perhaps discarded, became under his guiding suggestion a new pathway to understanding. Africa has one, China several, India one, and several active centers in the United States have young men who have profited from gifts of wisdom he imparted. Those of us who saw him day after day, constantly at work, but always ready to stop for questions, can never forget his example.

John Henry Schaffner was born in Agosta, Marion County, Ohio. He was educated at Baker University, Kansas; the University of Michigan, the University of Chicago, and the University of Zurich, Switzerland. In 1897, when he came to Ohio State as Assistant in Botany, with the late Dr. Kellerman as Professor, there were fewer students in the whole of Ohio State University, 1,200 or less, than there are now in the Department of Botany each year. Professor Schaffner's work

on chromosome behavior between 1894 and 1898 pioneered in the field that has now developed so richly in the application of Mendelism. His papers on the prairies reflect knowledge acquired during his boyhood familiarity with plants now long gone in regions where they were native. His papers on *Equisetum* cover a whole range of plant sciences focused on the single small group of plants he loved so well to study. His eleventh paper in a series on determinate evolution is just off the press two months after his death. With reference to man, in this paper, there is this sentence, "It has been estimated, on a conservative basis, that there are over twelve billions (12,000,000,000) of cells in the human brain alone, and it is evident that the self-conscious personality, my ego, controls this amazing mechanism and other billions of cells of the body to a definite purpose while this sentence is being written." It is a remarkable sentence in that it contains one of the few personal references in his entire writings. Yet even this slight reference to himself turns out, as the context of the paragraph reveals, to be a means of stating a concept of chromosome activity. He seldom thought of himself. His vacations, always with his family, were visits to Kansas, but for the sake of his children and Mrs. Schaffner as well as for the purpose of collecting specimens they often reached Kansas by way of Maine or the Pacific Coast.

Ohio was not neglected in the matter of plant records. The catalog of Ohio plants is as complete and the herbarium records as numerous as in any state record. Half of these have been added during the last two decades. Perhaps it was the devotion to the herbarium which brought on the heart attack, as it was evident to all of us that the climb of three flights of stairs was a severe strain. When space, more cramped of course than the herbarium, was offered in the basement with the assistants volunteering to do the errand running for changes of specimens to be studied, the answer was only a gentle No, that he preferred to be where all the stored specimens were at hand. The irony of this is that in the original plans for the building in 1914 an elevator to the herbarium was included. For lack of funds at the time this was not installed in the building.

Early in his association at Ohio State University he with the group that numbers Professors Landacre, Herbert Osborn, Raymond Osburn, James Hine, John Bownocker, and others, founded the Biology Club. This grew into the Ohio Academy of Science. Professor Schaffner was the Editor for its entire existence of the Ohio Naturalist, the predecessor of the Ohio Journal of Science. He was also editor of the Ohio Journal of Science from 1916 to 1918, its critical first two years. His services to the Academy in this respect are unique. He was its president in 1919.

We have lost a wise counsellor and a devoted friend. We cannot think of the man without his works, or the deeds without the personality that produced them. A full bibliography of his 330 papers and books will appear in another place. The Torrey Index lacks about a hundred titles of the full citation of his work. As editor, as teacher, as an example of a tireless investigator he leaves us a rich gift in his memory.

### *Report of the Nominating Committee*

*For President*.....WILLIAM LLOYD EVANS

*For Vice-Presidents:*

- A. Zoology.....JOHN W. PRICE
- B. Botany.....MISS LOIS LAMPE
- C. Geology.....OTTO C. VON SCHLICTEN
- D. Medical Sciences.....DR. GEORGE M. CURTIS
- E. Psychology.....FLOYD C. DOCKERAY
- F. Physics and Astronomy.....RAY LAMBERT
- G. Geography.....GEORGE D. HUBBARD
- H. Chemistry.....PAUL ROTHMOND
- I. Mathematics.....LEWIS BRAND

*For Secretary*.....WILLIAM H. ALEXANDER

*For Treasurer*.....EUGENE VAN CLEEF

*For Elective Members to the Executive Committee*....{ CLAUDE E. O'NEAL  
J. PAUL VISSCHER

*For Board of Trustees, Research Fund*.....CHARLES G. SHATZER

*For Joint Administrative Board, Ohio Journal of Science*, A. W. LINDSEY

*For Committee on Conservation*.....{ A. E. WALLER, Chairman  
EMERY R. HAYHURST  
L. E. HICKS  
PAUL B. SEARS  
WALTER A. TUCKER

*For Library Committee*.....DR. E. LUCY BRAUN

*For Representative on Save Outdoor Ohio*.....ROSCOE W. FRANKS

Respectfully submitted,

(Signed) HAROLD E. BURTT,

(Signed) W. P. SPENCER,

(Signed) R. A. DOBBINS,

(Others by proxy and correspondence.—HAROLD E. BURTT.)

### *Report of the Committee on Resolutions*

CINCINNATI, OHIO, April 14, 1939.

*Mr. Chairman, Fellow Members of the Ohio Academy of Science,  
and Friends:*

The Committee on Resolutions offers with great sincerity the following:

The Ohio Academy of Science is deeply appreciative of the complete hospitality offered by the University of Cincinnati. Everything has been done for our convenience and comfort. Not only has the University been placed at our disposal, but the city. Members of the Academy appreciate the welcome given them by Taft and Natural History Museums. For these evidences of friendship and hospitality the Academy is most grateful.

Secondly, the task of arrangements is a great and thankless one. We can not reduce the magnitude of the task, but we shall endeavor to

make it less thankless. Be it resolved, then, that Prof. J. Hobart Hoskins and the several members of the arrangements committee be hugely thanked for their effective labors.

A third resolution is hereby offered. Lectures given before the Academy as a whole are most exacting. The variety of interest of the audience demands unusual skill on the part of the lecturer. The Ohio Academy of Science congratulates Dr. Paris B. Stockdale upon his excellent presentation of the Geology of Hawaii, and the Academy finds itself equally indebted to Prof. Edwin L. Moseley for the lecture upon the important question of flood prediction, and Mr. Karl Maslowski for his charming "Naturalist's Diary."

The Fourth Resolution: No one has done more for the popularizing of economic ecological aspects of Botany than Dr. Paul B. Sears. Twice he speaks to the Academy during this session. Twice we are honored.

Respectfully submitted,

ARTHUR T. EVANS, *Chairman*,  
CLYDE S. ADAMS,  
RODERICK PEATTIE.

---

#### A New Treatise on Sedimentary Petrography

The field of sedimentary petrography has undergone notable expansion in recent years, in scope of study and wealth of technique as well as in extent of practice, and for some time there has been need for a thoroughgoing treatise on the subject. The present volume meets this need. It does so especially for methods of mechanical analysis and other treatment of purely physical attributes of sediments, the area in which much of recent progress has centered and for which adequate coverage has not been attempted in any general work hitherto published.

The book is in two parts, the first, by Krumbein, on mechanical analysis and allied subjects, and the second, by Pettijohn, on microscopic, chemical, and other methods. The parts are about equal in length, a proportion to be welcomed by the student especially interested in the mechanical constitution of sediments. On the whole the material is clearly presented and well illustrated, and an outstanding feature of the work is its thoroughness in scope; no important aspect of sedimentary petrography is neglected. It is restricted, however, to method and underlying theory, and no venture is made into the realm of interpretation—doubtless a wise limitation, considering the present status of knowledge respecting the significance of physical features of sediments.

If any major aspect of the book is to be adversely criticised, it is the over-thoroughness with which the mathematical and statistical treatments of analytical, data are presented. Much of the first half of the work is devoted to these subjects and some of the discussion is more elaborate than necessary for a book of this sort. The authors are justified in emphasizing these important subjects, but they might have done so at lesser length. For example, in the description of an effective and simple method of graphic differentiation for the determination of frequency distribution curves, mathematical proof is given in full, whereas reference to the easily accessible article in which it has already been published would have sufficed. However, if there is to be error in the matter of completeness, it is far better on the side of amplitude than otherwise.

Especially desirable is the treatment of methods for dealing with sedimentary rocks, which commonly present great difficulty to the laboratory worker, either in disaggregation or in thin-section study; no complete and satisfactory discussion of this subject has hitherto been available in any form.

On the whole this is an excellent book, indispensable to the student of sediments and sedimentary rocks.—*Edmund M. Spieker*.

**Manual of Sedimentary Petrography**, by W. C. Krumbein and F. J. Pettijohn. New York, D. Appleton-Century Co., 1939. \$6.00.

## PRESIDENTIAL ADDRESS

CLAUDE E. O'NEAL,

Delaware, Ohio

Coming to Cincinnati is not a new experience to most members of the Ohio Academy of Science. This is our forty-ninth annual meeting and the fourth to be held in what has been called the Queen City of the West. We have learned to expect an inspiration from just coming here. It would be difficult to find a more ideal place for a scientific gathering. The Ohio Valley itself is interesting and the numerous mounds scattered over Hamilton County remind us again of a people who lived here long before the coming of the white man.

From its very founding in 1788 Cincinnati has been known as an educational and industrial center. In its early years it became famous for its art, its literature, its music, and its science. More recently its numerous educational institutions, its newspapers, its publishing companies, its many industries, not to mention its radio broadcasting stations, have reminded us that she still is on the map as a center of industry, culture and refinement. It is good to come to Cincinnati.

And the University of Cincinnati has always opened its doors wide to the scientists of the state and the nation. It has always displayed a co-operative spirit toward scientific investigation, and this has resulted in the kindest feelings on the part of those engaged in scientific work. We thank you for your greetings as well as for the use of your class rooms, lecture halls and equipment. You have made us feel most welcome.

I would like to recall an incident that occurred in your city or very near it, certainly in Hamilton County, 125 years ago. I shall quote from an historical record of that early day. "One of the most wealthy and respectable farmers living near Mill Creek, and who had expended much money in procuring and propagating a fine breed of horses was unfortunate in losing a number of them by distemper which appeared to be of a novel character. As the disease baffled his skill, he soon became convinced that it was the result of witchcraft. Under that impression, he consulted those who had a reputation of a knowledge of sorcery for a remedy for his horses. These persons told him how to discover and how to destroy the witch. One



of the experiments that he was directed to make was to boil herbs and other ingredients in a pot in which he had placed a handful of needles and pins. This, he was told, would cause great mental and physical distress to the witch or wizard. He tried the experiment and while the pot was boiling furiously, he placed himself at the door overlooking the field in which his horses were kept. While in that position he saw his own daughter-in-law, who lived about a quarter of a mile away, hastening to the spring for a bucket of water. His imagination connected her hurried movement with his incantation so strongly that he ordered his son to move his family away from the farm.

"Later, he became of the opinion that a Mrs. Garrison, an elderly woman in feeble health, and who lived some eight or ten miles from his farm, was the principal agent in the destruction of his horses. He frequently expressed this opinion to his neighbors and Mrs. Garrison heard of it and was greatly distressed. . . . One of the charms that he had been directed to use was to shoot a horse with a silver bullet while the witch was evidently in him. He accordingly prepared a silver ball and shot a fine brood mare with it. The horse was killed and a short time later, Mrs. Garrison died. The farmer, we will all agree, believed to his dying day that his silver bullet had killed her."<sup>1</sup>

It is a long throw from such a quag-mire of ignorance and superstition as this to the typing of the pneumococcus and the preparation of the sulfanilamide tablet. It is highly fitting that today one of the outstanding medical schools of the country should be located so near the spot where this pioneer farmer lived and suffered. It is equally fitting, too, that every branch of science represented in our organization should be so adequately cared for on this campus. A long time ago a Great Teacher said, "Ye shall know the truth and the truth will make you free." Truly this has come to pass and is coming to pass in the University of Cincinnati. Doctor Gowdy, we thank you for your greetings.

I should like to take this opportunity to thank all persons who in any way have aided in the work of the Academy during the past year. I refer especially to the officers and the members of the numerous committees, the mere cataloging of which,

---

<sup>1</sup>Quoted (not verbatim) from Howe's Historical Collections of Ohio, Vol. 1, p. 760.

I fear, may be somewhat boresome. Nevertheless these men have given unstintedly of their time and efforts and appreciation should be shown. The Executive Committee, for example, has held itself subject to call throughout the year and has received and replied to an almost continuous barrage of letters from the President's office. I desire to convey to them my sincere thanks.

#### TAKING INVENTORY

From time immemorial, business organizations have found it worthwhile to take time out for invoice. Within the recollection of persons here assembled business houses were closed for a time each year, while goods on the shelves were listed and evaluated, bad accounts were written off, and new orders were made out. It would seem that the scientists of the state and of the world could profit by taking a cue from this practice. Certainly they need to know what their assets are, in what direction they are going and what progress is being made.

A casual survey of the field of scientific achievement shows at once that a tremendous volume of facts has been discovered, classified and made available to those who would use it. At no time has the machinery for the dissemination of knowledge been in better condition or so effective. The press, the radio, and the movies can make the result of a scientific discovery or invention common property within a few hours. At no time in the history of the world has the hypothetical man of the street been so well informed of scientific phenomena as he is today. "Those who have eyes to see, may see; and those who have ears to hear, may hear." All of this we may write on the black side of our ledger.

However, when we look at the effect of all of this information and means of ready erudition upon the thinking of the individual and of masses, the picture is not so bright. It would seem that those who are college trained should profit most from the fund of knowledge and should be most influenced by it, yet Everett Dean Martin writes, "The college man shares the usual prejudices of his community. He runs with the crowd after the hero, and shows the same lack of discrimination as do the uneducated. He votes the same party ticket, is intolerant along with his neighbors, and puts the same value upon the material as the illiterate do. His education has made very little difference in his religious beliefs, his

social philosophy, his ethical values or his general outlook on the world. Like all opinionated and half educated people, he jumps to vast conclusions, believes what others believe, does things as others do them, worships the past and idealizes the present."<sup>2</sup>

May I relate a personal incident? A few summers ago I was invited by the director of a boy's camp to take his proteeges on a hike. In my preliminary remarks to the boys, I complimented them on the fine appearance of their camp and mentioned particularly some granite boulders which had been arranged in a large circle and painted white, so that the effect was quite like a fairy-ring of giant puff-balls. I told the boys that had the stones been puff-balls and had we been in England or Germany, many people would hesitate to step into the ring for to do so would mean placing themselves under the control of the fairies in England and the witches in case we were in Germany. But, I told them, we were in America and to show them that I was not superstitious, I was going to step into the ring and if any of them were not, they might do so too, and we would start the field trip right. They came with a yell and I as their leader started off on a half run. I had gone perhaps fifty yards when my right foot struck a stone and my right ankle was sprained severely. I tried to catch myself with my left foot, but it landed in a cowtrack and my left ankle also was sprained. I need not describe the rest of the field-trip, but the next day I had a caller, a college graduate of several years standing, who came not so much to express sympathy as to warn me against what he called "the intimidation of unseen forces." When I realized his utter seriousness, I told him that I was of the firm opinion that had I had on my high-topped boots, properly laced, that it would not have happened. His reply was, "Well, anyway, you have been warned." (And this was 115 years after the witchcraft incident, that I mentioned at the outset.)

The college graduate mentioned was not particularly trained in the field of science, but had he been are we sure that his reactions would have been any different? In the circle of my acquaintances is an astrologer who was trained as an electrical engineer. Incidentally, he is making more money from horoscopes than he ever did from wiring dynamos.

---

<sup>2</sup>Martin, Everett Dean. *The Meaning of a Liberal Education*, p. 82. W. W. Norton Co., New York, N. Y.

It would not be easy for this group to come to an agreement upon the ultimate aims and objectives of science or science teaching. I certainly have nothing new to propose along this line, but as long as there is ignorance, superstition, disease, injustice, social inequality, crime, economic mal-adjustments, political chicanery, intolerance and war in the world, there is a place for the scientist and for scientific thinking. This implies that not all scientists can hope to remain or to become laboratory hermits, lost to the world about them. Many have already taken their places in the social order and more should do so with the idea of seeing to it that the methods of science are applied for the good of all mankind.

In 1938, the British Association for the Advancement of Science, at its annual meeting, voted to establish a division to deal with the social and international relations of science. "The main purposes of the Division are to further the objective study of the effects of advances in science in communities and reciprocally the effects of social conditions upon the progress of science; and, to encourage the application of science to promote the well-being of society."<sup>3</sup> (The improvement of international relations is considered a social problem.) Already the British Association has made wide contacts with scientists of various countries and lay interests in the work of the Division. Of course, this is just one straw, but it may indicate the direction toward which the scientific wind is turning.

Science has done much to ameliorate the needs and hardships of mankind, and this work must continue; but as time goes by, it seems likely that it also will have to indicate the means whereby its blessings may be made more generally available to all.

And, now, if we may come a little nearer home, let us glance at the status of the science work that is being done in Ohio. Much of this work is carried on in the colleges and universities with which the state is so abundantly provided. Most of us in the smaller institutions are ready to confess that we are not doing as much first hand investigating as we should. We are inclined to plead the excuse of too many classes, too many committee meetings, too many social engagements, too many interruptions, and general lack of atmosphere. In the larger institutions enormous classes, heavy teaching loads, and some-

---

<sup>3</sup>From a brochure published by the British Association for the Advancement of Science.

times crowded quarters and lack of funds make for a situation almost equally difficult. As a result the question might be raised as to whether or not a too-high percentage of our scientific work is being done as theses requirements for advanced degrees. Be that as it may, progress is being made and will continue to be made in the state of Ohio.

The Ohio Academy of Science is the one outstanding scientific organization in our state which attempts to bring together in a single body the workers in the various fields of endeavor. Reasonably, it might be expected to appeal to nearly everyone working in the field of science within our boundaries, but for the last twelve years, our membership has just about held its own. At the 37th annual meeting the statement was made that we had slightly over 500 members. A similar statement could have been made at the beginning of this year. Someone may say at once that we are large enough, and possibly this is correct, but the state just west of us with many less colleges and universities as well as large cities, supports an Academy of about 900 members.

It may be beyond my ability to determine the reasons for this discrepancy, but as a member of both organizations, I should like to point out certain obvious facts. First, there is a more wide spread interest on the part of the young scientists in Indiana in becoming members of their Academy. Possibly this is due to the fact that they have a junior membership who at a tender age become interested and later full-fledged members. I am pleased to note that we are taking steps in this direction at our forty-ninth meeting. Our sister Academy has kept its membership fee at \$1.00 and the papers read before it are published in a single bound volume.

It may be argued that anyone can pay \$2.50 per year for membership, but in these days of curtailed incomes, it is more difficult for many people to justify even this small expense. This is especially true of the younger group from which our new members logically should come.

During the present year the Executive Committee instigated a campaign to increase our membership. You have heard the slogan that was adopted, "One thousand members by 1940." This is not an impossible goal, if we can assure the incoming members that they will receive full value for the \$2.50 which they give us. To do this will require the wisest counsel which we can afford, as well as the co-operation of our entire present

membership. And, I wish to say right here, that we are very fortunate in having Dean Arps as a member of the Ohio Academy of Science. We are doubly fortunate in that he has agreed to act as the Director of our Semi-Centennial Celebration. He already has his shoulder to the wheel and it is beginning to turn. He needs and expects the co-operation of each of us. In a few minutes Dean Arps will tell us of the plans for our Semi-Centennial Celebration. This celebration as well as at least two other meetings of national note to be held in our state next year should aid very materially our drive for new members.

In passing, may I express the opinion that the Academy has not received the publicity in the past which the interest and importance of the papers presented before it have justified. We have just about discontinued the practice of requiring abstracts before papers are read. Yet, if this were done, a copy could be sent to Science Service, Washington, D. C. This agency welcomes such material but agrees to use only that which is of general interest. Another copy could be sent to the local press representatives in the city in which the meeting is held. A third copy should be reserved for filing. It will be noted that this suggestion does not involve the expenditure of money, and is already being followed by other Academies.

The man in our organization who probably knows most about administrative matters says that what the Ohio Academy needs worst, is a good administration. After my year's experience, I am inclined to agree, but would like to point out one procedure in our set-up which makes it very difficult of fulfillment. In the past your President has had to assume executive duties immediately upon election. There is no objection to this practice, if the man elected is conversant with the intimate workings of the organization, but it frequently happens that he is not. This condition could largely be obviated by electing our President a full year ahead and asking that he serve on the Executive Committee for the intervening period. Other possibilities of improvement will occur to the members of the Council as they study our best interests.

In conclusion, let me say that I have no fears for the scientific progress of the future. The eternal question mark in the mind of man will care for that; and for the Ohio Academy of Science I dare predict a wider sphere of usefulness as the years go by.

# LONG TIME FORECASTS OF OHIO RIVER FLOODS

E. L. MOSELEY,  
Bowling Green State University  
Bowling Green, Ohio

Had we known ten years ago what we know now about cycles of precipitation we could have predicted heavy rain for the Ohio valley in the winter of 1936-'37. That the most disastrous flood in its entire history would come at that time we could not have foreseen.

The amount of destruction wrought by a flood depends on many things besides the amount of rain at the time. Nevertheless, major floods in the Ohio River have probably rarely, if ever, occurred without more than the average amount of rain over the drainage area of some of its tributaries not very long prior to the flood. Heavy precipitation is a major factor in flood production.

Twenty-nine times in the past eighty years the gauge at Cincinnati has shown the river to be more than 55 feet above the zero mark. This occurred once in August and once in December, but 27 of these 29 floods occurred in the first third of the year—6 in January, 9 in February, 8 in March, 4 in April. In predicting major floods a knowledge of prospective rainfall in spring and summer is of less importance than that of winter. If heavy summer rains keep the ground wet until late fall, less rain will be needed later to start the water flowing in drain tile and ditches, but the amount of precipitation in late fall and in winter is of more importance in flood production.

There have been periods of several years without great floods and periods of similar duration with several great floods. The Annual Meteorological Summary for Cincinnati gives the highest stage of the river for every year from 1867-1937. Within this time the river was above 55 feet 24 times, but only eight times in isolated years. The other 16 floods occurred in years that were just before or just after a flood year. Thus there was a major flood in 1882, in 1883, and in 1884, also in 1897, 1898, and 1899. The Pittsburgh record shows the same thing; major floods occurring singly were much less numerous than those occurring in successive years.

We have good reason to believe that variations in the emission of solar energy, both in total quantity and in the

proportional amount of ultraviolet rays, are in some way responsible for at least a part of those changes in the terrestrial atmosphere which we commonly speak of as weather. How they influence weather is not yet well understood. Quite likely the sunspots themselves do not play an important part, but their presence in large numbers indicates increased activity in the solar atmosphere, accompanied by emission of more heat. Strange to say our thermometers at such times register lower temperatures. This paradox is not so easily explained as the fact that our winter comes when the earth is nearest the sun, for the lowering of temperature at times of sunspot maxima is not confined to either hemisphere. The increased heat from the sun causes more storms with attendant clouds that intercept part of the sun's rays before they reach the solid earth. These storms also cause an overturning of the atmosphere resulting in a mingling of cool air from above with the air near the earth's surface.

Just as a violin string vibrates as a whole and at the same time in parts, so the curve representing the sunspot numbers shows a fundamental period and other periods which may be called harmonics. The fundamental, although variable, averages more than eleven years. Corresponding to this period I have found variations in rainfall in the Ohio valley. In arid regions of the Southwest, where rain is the all-important factor in tree growth, Professor Douglass of the University of Arizona has found that not only the fundamental but also the harmonics in the curve of sunspot numbers show in the tree rings.

Each of these short periods in the sunspot curve probably has some influence on our weather. Their combined effect at any particular time depends on the phases which come together at that time. This changes from year to year, but since the fundamental and the harmonics are all submultiples of about ninety years they combine again after this interval in the same phase as at the beginning.

Professor Kullmer of Syracuse University has found that the centers of greatest storminess over the United States and Canada shift in both latitude and longitude. After moving east for a number of years the location of these centers returns abruptly to a position much farther west. It may be that after ninety years the storm centers return to very nearly the same place which they had at the beginning. The data available for his charts do not cover a long enough period yet to tell whether there is a basis of fact in this hypothesis.



My early work with tree rings consisted mainly in laying off 46-year periods, later changed to 45-year periods, and measuring the radial growth increment during each of these periods. The period starting with 1891 I called Period 1, the preceding 45 years Period 2, and so on. I found that in Period 2 a majority of trees made more growth than in Period 1 or 3, and that all even numbered periods were wet ones, odd numbered periods, with one exception, dry ones. Consequently twice 45 years takes us from the beginning of one wet period to the beginning of another wet period, and likewise from any part of any period to the corresponding part of another similar period.

Thus there are some theoretical grounds for the idea that precipitation in any given region in this part of North America comes in ninety-year cycles. That there actually is a repetition of drought and flood after the lapse of about ninety years we have abundant evidence. It comes from four sources: Great Lakes levels, tree rings, high and low water in rivers, and actual records of rainfall. Early records of unusually high or low water in the Great Lakes are scanty. More of them relate to Lake Ontario than to any other lake, for on its shores there were settlements earlier than about the lakes farther west. Since it receives most of its water from the other lakes its level is an index of rainfall over a large area. When it was unusually high this was noticed and in some cases a record made of it. About ninety years after each of these early years of high water in the Great Lakes there was high water again.

On the terminal portion of the Cedar Point peninsula, which lies between Sandusky Bay and Lake Erie, are long parallel ridges formed of gravel and sand. Each ridge was built by a great northeast storm occurring at a time when Lake Erie was unusually high. Only at such times was it possible for the wind to drive the waves far back on the land and throw up ridges which would not be demolished by a later storm. Early in the present century, accompanied by boys from the Sandusky High School, I made many trips to Cedar Point for the purpose of determining when these ridges were formed. The methods we employed and the dates which we finally assigned as a result of this research were made known to the Ohio Academy of Science at its annual meeting in Cleveland in 1904.<sup>1</sup> Two of the ridges were formed in the nineteenth

---

<sup>1</sup>Thirteenth Annual Report, Ohio Academy of Science, pp. 223-231.

century, one in the eighteenth, one in the seventeenth, two in the sixteenth and one in the fifteenth.

The dates which we assigned to the ridges that were built in the nineteenth century we had reason to believe were correct within two or three years. We did not suppose that such close approximation was true also of the dates of ridges formed in the earlier centuries. Not until recently did I know anything about cycles of precipitation. In view of this fact it is significant that a succession of ninety-year intervals is clearly shown by these dates. Three of the dates are 1504, 1594 and 1684. Ninety years later no permanent ridge was formed, but 180 years later, 1864, is very close to the time that ridge 6 B was formed, 1861 or 1862. The date assigned to the oldest ridge is 1429. Five times 90 (450) years later is 1879. The date assigned to the latest of these permanent ridges is 1878.

A living tree forms a new ring of wood each year just beneath the bark. These annual rings, as they are called, show by their thickness whether the tree was getting more or less than the usual amount of moisture at the time the ring was formed. A study of these rings after the tree is cut down makes it possible to learn about the rainfall during the life of the tree. I have made measurements on the tops of stumps, the ends of logs, or on cross sections taken from them, representing more than four hundred large trees that grew from southern Michigan to central Tennessee. A large part of these trees were between 200 and 370 years old, a few were still older and so afford information about the rainfall each year for the past four centuries. They show plainly a tendency to repeat after about ninety years.

The dates when the trees formed rings which were obviously wider or narrower than neighboring rings were recorded for about 125 trees, of which a large majority were oaks. These records form the basis for the table of wide and narrow rings. (See Table I.)

Records of Ohio River floods at Pittsburgh go back to 1762, which is 26 years before there was any permanent settlement in Ohio. Until after 1832 there were only seven floods so important that they are shown on this record. Each of these was followed by a flood approximately ninety years later, the water usually reaching a height similar to that of the earlier flood. There were six floods in the years 1846-'52; no

other comparable period in the nineteenth century had so many floods when the Ohio River reached such high levels. This corresponds to the period 1936-1942, which has already given three major floods.

TABLE I

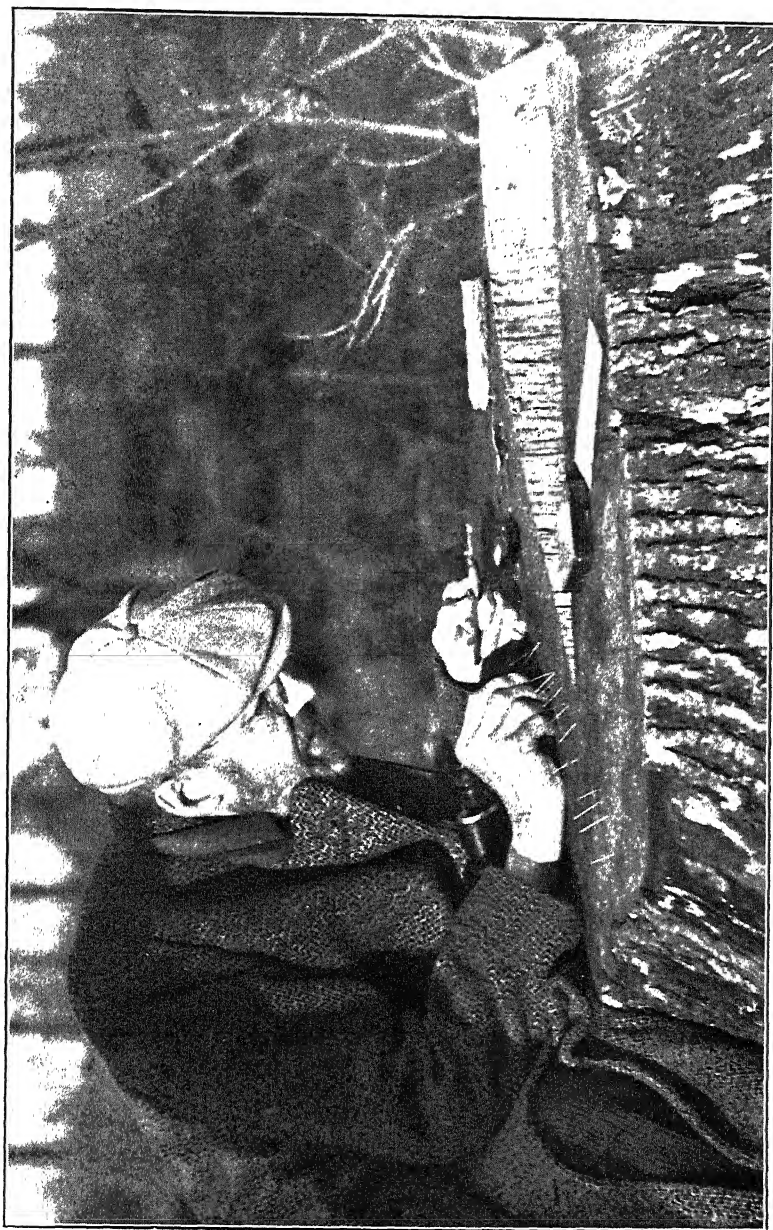
YEARS WHEN A MAJORITY OF THE TREES IN THE REGION EXTENDING FROM SOUTHERN MICHIGAN TO TENNESSEE FORMED WIDE OR NARROW RINGS

	WIDE			NARROW			
	1852	1761	1671	1936	1845	1755	1665
	1850	1760	1669	1934	1843	1753	1663
1939 (?)	1849	1759	1668	1931-2	1841	1751	1660
1938	1848	1758		1930	1839	1748-9	1658
1937	1847	1756		1925	1834	1743-4	1652-3
1928	1837	1747	1657	1911	1821	1730	1640
1927	1836			1910	1820	1729(?)	1639 (?)
1922	1832	1741		1907	1816	1726	1636
				1901	1811	1721	1630
	1887	1797	1707	1900	1810	1720	1629 (?)
	1886	1796	1706	1898-9	1808-9	1718	1628
	1885	1795	1705	1895	1804	1714	1624
	1884	1794	1704	1894	1802-3	1712-3	1622-3
	1883	1793	1703	1891	1801	1711	1620
	1881	1791		1890	1799-0	1709-0	1618-9
	1878	1788	1697 (?)	1874	1784	1693	1603
	1877	1787	1696	1871	1781	1691	1600
	1876	1786	1695	1870	1780	1690	1599
	1869	1779(?)	1688	1868	1778	1687	1597
	1859	1769	1678	1867	1777	1686	1596 (?)
	1858	1768	1677	1864	1774	1683	1592
				1857	1767	1676	1585
				1856	1766	1675	1584

The table shows that each wet year was followed after an interval of 90 or 91 years by another wet year, likewise each dry year by a dry year. If the precipitation cycle were as long as ninety and one-half years, the 91-year interval would appear as often as the 90-year interval, but it does not. If the cycle were just ninety and one-third years, then after three such intervals the difference between dates would be 271 years, as it usually is, but in some cases it is 272 years, which implies that the cycle is a little more than ninety and one-third years.

By using records of rainfall prior to 1848 many attempts have been made to correlate months of excessive or deficient rain with months between 90 and 91 years later. The best correlations were found by using the months ninety years and five months later, the next best by using an interval of ninety years and four months. This result is in good agreement with the table of dates of wet and dry years shown by the width of tree rings. Both methods lead to the conclusion that the length of the cycle is not far from 90.4 years.

The first two floods recorded at Pittsburgh, 1762 and 1763, were among the greatest in the entire record. Ninety years after 1762, that is in 1852, the river at Pittsburgh rose to 35.1 feet, almost as high as in the great flood of 1884, and higher than at any other time in the century preceding 1936. It lacked only one foot of attaining the same height a few months earlier, September, 1851. This is the only time that two such



Bur oak stump 47"  $\times$  52", 30" high, Allen county, Indiana, May 2, 1939. It shows 283 annual rings.  
Photo by O. E. Ehrhart, Antwerp, Ohio.



high floods have occurred there within so short a period in the entire 175 years of the Pittsburgh record. Ninety years after 1852—twice ninety years after 1762—will be 1942. Farther on we will consider the probability of a great flood then.

Tree rings show that there were copious rains over a wide area in the years 1846-'52, also in 1756-'62, and 1666-'72, that is at intervals of ninety years.

These great floods of course affected the river also along the West Virginia, Kentucky, and Ohio border, where there are records of a few other early floods. At Cincinnati the highest water that old residents could remember prior to the flood of 1937 came in 1883 and '84. Each of these great floods followed ninety-one years after a great flood; that of 1792 reached a height of about 63 feet, that of 1793, 57 feet. Tree rings for all four of these great flood years have been observed on stumps and logs in seven states; they all show heavy rainfall. Ninety years earlier still, 1702 and '03, a majority of the trees produced wide rings.

We are now ready to see how this tendency of heavy precipitation to repeat itself after 90.4 years might have been used in predicting recent floods. Let us consider first the rainfall 90.4 years prior to the terrible flood in January, 1937. This takes us back to the summer of 1846. That year the rainfall at Cincinnati and Dayton was above normal every month from April to August; in some of these months it was very much above normal, double or nearly double. Marietta had over 19 inches of rain in three months, June, July, and August. Steubenville, still farther up the river, had 22.79 inches in four months, May to August. Pittsburgh had double the normal amount, July and August. Portsmouth, Ohio, and Springdale, near Louisville, Kentucky, also had heavy rain at that time. Such rain in the summer of 1846 would have justified predicting a serious flood in the Ohio River in the winter of 1936-'37.

The great flood of 1936, which at Pittsburgh was even greater than that of 1937, came two months later in the year than that of 1937, as might have been expected from the fact that heavy rain in 1845 started later and continued later. That year Cincinnati had  $11\frac{1}{2}$  inches of rain in June and 14.39 inches in the two months August and September.

In 1847 there was a surplus of rain along the Ohio River from Pittsburgh to Louisville in June and July, likewise 90.4

years later, October and December, 1937. There would have been a flood in January or February, 1938, if heavy rains had continued, but in August, 1847, rainfall was below normal, likewise in January, 1938, it was below normal. So 1938 did not, like the preceding years, give a major flood.

The year 1848, like the years before and after, gave more than the usual amount of rain in the Ohio valley. There was a large surplus in May and a very large one in July, followed by a surplus of one inch in August. 90.4 years later came the winter of 1938-'39, with a flood which drove many thousands of people from their homes.

Every major flood which has occurred from 1913 to the present was preceded by heavy precipitation about 90.4 years before. Marietta is the only Ohio River station whose record goes back 90 years earlier than 1913. It had almost double the usual amount of rain in September, October and November, 1822. The tree rings formed in 1822 and 1823 indicate that more rain fell in those years than in any two previous years in the century.

In September, 1848, rainfall in the Ohio valley was below normal, in October and November it was about normal. The corresponding part of 1939 is from February, or a little before, to about the present time. December, 1848, brought heavy rains all along the Ohio River, also in western New York, central Pennsylvania, eastern Missouri and Iowa. At Cincinnati and Springdale there was more than ten inches. The following month the rainfall was not so great but, nevertheless, was double the normal at Cincinnati, Dayton, and St. Louis, and above normal at most places. We may expect heavy rains in the next two months.

In February, 1849, at a majority of places in this part of the country rainfall was below normal, in March it was well above, in April, May and June it was near normal. Accordingly we may look for about the average amount of rain in the five months, July to November, taken as a whole.

July, 1849, gave a very heavy rain—on an average more than nine inches at Dayton, Cincinnati, Portsmouth and at St. Louis, Missouri; but in eastern Ohio, Pennsylvania and New York rain that month was below normal. About December, 1939, rain should be heavy from Cincinnati to St. Louis. In August, 1849, rain averaged about normal along the Ohio River, in September rain was light at all stations, in October

it was about double the normal at some stations, in November it was below. Judging from these data I think there will not be a major flood in the Ohio River in the early part of 1940. The Mississippi River will be unusually high above St. Louis and perhaps also farther south, throughout much of the winter of 1939-'40.

In 1850 the rainfall at Cincinnati was 54.56 inches, exceeding that of any year since. Portsmouth had 57.20 inches, which is more than in any other year in its entire record of over a century. Springdale, Kentucky, had still more rain that year, 67.10 inches, which was also its maximum. 1850 was a wet year also in the Eastern States. All along the Ohio River there were excessive rains the last month of 1849 and the first part of 1850, continuing through March at most places. So we may expect copious rains, May to August, 1940. If great floods in this river were not so rare in summer, I would expect one in the summer of 1940.

In the summer of 1850 rainfall was heavy at Cincinnati and Springdale, but not along the upper course of the river. There is not likely to be a major flood in 1941.

Rainfall was double the normal in December, 1850, at four of the six stations along the Ohio River, but in nearly every month of 1851 it was below normal at all stations. Therefore we may expect less rain from June, 1941, to May, 1942, than in any other twelve month period in the seven wet years which began late in the summer of 1936. This does not mean, however, that there will be a drought at that time.

In 1942 the river should rise in July and August and become high in September. During the remainder of the year rainfall should not average much, if any, above normal.

Since there was a great flood in 1762 and another in 1852, we might expect another about 1943. Let us consider the probability of it on the basis of rainfall in 1852. In July it was below normal at all Ohio River stations, in August and September about normal, in October below normal at all stations. Hence December, 1942, and the first three months of 1943, taken as a whole, should not have precipitation above normal.

November precipitation in 1852 was well above average in four places on the river and at Richmond, Indiana, whose record started with that year. In the following month Richmond had 11.20 inches, or four times the normal. At other



places the average was about double the normal. Hence the river should rise in April, 1943, and in May become unusually high for that month.

In 1853 average precipitation was low at Ohio River stations, also in 1854 in part of them, in summer low at all of them. It was also rather low in the first four months of 1855. Hence there should be no very high water after the spring of 1943 until late in 1945.

In the summer of 1855 rainfall was excessive all along the river from June to September, at some places also in May. This implies high water from November, 1945, to February, 1946. If much of the precipitation in early winter falls as snow that remains long on the ground, there will be a flood when it melts if a large amount melts in a short time.

There will be high water at this time also in Pennsylvania, New York, and northern Ohio, resulting in floods, especially if much snow melts quickly.

After the spring of 1946 until late in the following year we think there will be no great floods in large streams in southern Wisconsin, eastern Iowa, Illinois, Indiana, Ohio, Kentucky, Pennsylvania, or New York.

In the spring of 1946 there should be abundant rain for crops that mature before mid-summer, but after that we may expect a drought that will continue until late in 1947. This drought will be of wide extent, in this part of the continent, but will not be felt everywhere. Tree rings show that the growing season of 1856 was dry from Michigan to Tennessee, in many places very dry. Weather records at those places in this area where the year 1856 is included show the same thing. Nearly all the trees show a narrow ring also in 1766, which was ninety years earlier. Ninety and ninety-one years before that, the growing seasons of both 1675 and '76 were dry. In 1584 and '85 the trees formed rings that were very narrow.

In 1856, which over a large area was one of the driest years of the nineteenth century, New Orleans and Baton Rouge each had 67 inches of rain. More than usual fell also at St. Louis, Missouri, Fort Madison and Monticello, Iowa, Kearney, Nebraska, Leavenworth, Kansas, and Fort Gibson, Oklahoma. Rainfall was below normal at other places in Iowa and much below in southeastern Texas, Pennsylvania and parts of New York State.

There will be plentiful rain again in 1948, 1949, and indeed in a majority of the years until the last quarter of the century.

In summary, nearly all of the great floods of the Ohio River have occurred in the first third of the year. Excessive precipitation 90.4 years later falls in summer. Nevertheless floods early in the year are likely to recur after ninety or ninety-one years, because precipitation oftentimes is high not only at the time of the flood but also in the summers preceding and following the flood. Wet years, like the floods themselves, show a tendency to occur in groups.

There will be high water in the river several times before the middle of 1943. These include May and June of the present year, the summer of next year, the latter part of summer in 1942, and the spring of 1943. In the five years following the spring of 1943, if a great flood occurs, it will probably be in the winter of 1945 to '46.

---

### Quantum Mechanics

A feeling is rapidly crystallizing itself among the physicists in our colleges and universities that a graduate student should as early as possible be given an introductory knowledge to quantum mechanics in order that he may make use of it in his other work. Recognition of the fact that classical physics is inadequate for the treatment of problems throughout atomic and molecular physics almost forces this point of view upon one. One is moreover nearly compelled to recognize that to the beginner it is more important to make use of the formulation of the new mechanics to work out problems in modern physics than it is to know the entire philosophical background for it. The student in elementary physics is not at once taught the philosophical structure underlying the Newtonian mechanics, but is made to work problems concerning pulleys and levers. It seems reasonable to start the beginning student in modern physics by working simple problems rather than with the uncertainty principle.

The Introduction to Quantum Mechanics by Rojansky is written from this point of view. It assumes as a prerequisite only the elements of the calculus and the ordinary differential equations. It is not given over to rigorous proofs or derivations, but aspires rather to give a plausible presentation of the point in question. It is not a book for the advanced student in quantum mechanics, although even he will often find it useful, but is written definitely for the beginning graduate student.

In the chapters I and IX are treated the more mathematical aspects of the quantum mechanics, while chapters II-VIII and X, XI treat one dimensional problems in quantum theory. In these chapters the problems are reviewed from the classical method of approach and subsequently in the Schrödinger, Heisenberg and Dirac formulations. Chapter XII is devoted to three dimensional problems and in the last two chapters the Pauli and Dirac theories of the spinning electron are discussed. Each chapter contains a list of carefully chosen problems and exercises to illustrate the reading material of the chapter.

This work seems to fill a demand which has long existed and it can be sincerely recommended as a text for courses in elementary quantum mechanics. It should prove useful to many others, especially to experimenters for whom it is important to have at least a general knowledge of the theory.—*H. H. Nielsen.*

**Introductory Quantum Mechanics**, by Vladimir Rojansky. x+544 pp. New York, Prentice-Hall, Inc., 1938. \$5.50.

# ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. VII\*

JOHN H. SCHAFFNER and CLYDE H. JONES

Our enthusiastic amateur botanists have contributed their usual large number of specimens during the past year. These contributions have greatly augmented our knowledge of the diversity and the distribution of the flora of Ohio.

The work performed by a number of N. Y. A. students has been very important from the standpoint of preserving the many valuable contributions donated by collectors through the years. The extermination of insects, replacing of illegible labels, and the cleaning and repairing of damaged herbarium sheets are a few of the many tasks performed by these students. Our State Herbarium is one of the best, and no effort should be spared to maintain that status.

The plants included in the following list were selected by Professor Schaffner from the contributions of the past year which he had examined. The unexamined collections will, undoubtedly, yield many more important and interesting records which will be given proper recognition in next year's report. The contributions so far examined have brought to light 10 species new to the state and important range extension of 59 others.

A recent survey of the 2,488 species, represented by 55,000 sheets in the State Herbarium, indicates that there are 536 species which have been reported from less than five counties in the state. A list of these species will soon be available to collectors and should be an aid in establishing authentic records of the true status of our rare or seldom collected native vascular plants.

1. *Ophioglossum vulgatum* L. Adder-tongue. Athens Co. Walter P. Porter and P. S. Wamsley.
- 25a. *Asplenium platyneuron* x *Camplosorus rhizophyllus* (A. ebenoides Scott). Muskingum Twp., Washington Co. George R. Procter. In Marietta College Herbarium.
51. *Isoetes engelmanni* A. Br. Engelmann's Quillwort. Pleasant Twp., Clark Co. Clyde H. Jones.
- 82.1. *Sagittaria longirostra* (Micheli) J. G. Sm. Long-beaked Arrow-head. Along Maumee R. near Napoleon, Henry Co. Floyd B. Chapman and L. E. Hicks.
113. *Najas gracillima* (A. Br.) Magnus. Thread-like Naias. In quiet pool of Portage River, Ottawa Co., probably near Port Clinton. In University of Michigan Herbarium. A. J. Peters (1898). Reported by Carl O. Grassl.
- 114.1. *Cabomba caroliniana* Gr. Cabomba. Holden Arboretum, Buttonbush Bog, Kirtland Twp., Lake Co. J. W. Aldrich.

---

\*Papers from the Department of Botany, The Ohio State University, No. 419.

- 119.1. *Anacharis planchonii* (Casp.) Rydb. Narrow-leaf Water-weed. Lake Alma, Jackson Co. Harold L. Edmonds.
122. *Sparganium androcladum* (Engelm.) Morong. Branching Bur-reed. In Buttonbush Bog, Kirtland, Lake Co. J. W. Aldrich.
166. *Stenophyllus capillaris* (L.) Britt. Hair-like *Stenophyllus*. Sandy Springs, Adams Co. F. B. Chapman.
157. *Dulichium arundinaceum* (L.) Britt. *Dulichium*. In bog, Madison Twp., Scioto Co. Floyd B. Chapman and Conrad Roth.
171. *Cyperus ovularis* (Mx.) Torr. Globose *Cyperus*. Common on sand ridges, Liberty Twp., Wood Co. R. E. Shanks.
225. *Carex cephalantha* (Bail.) Bickn. Little Prickly Sedge. Lake-O-Springs, Jackson Twp., Stark Co. Don M. Brown.
305. *Carex cryptolepis* Mack. Small Yellow Sedge. Lake-O-Springs, Jackson Twp., Stark Co. Don M. Brown.
325. *Arundinaria tecta* (Walt.) Muhl. Cane. Spreading from clumps planted many years ago. Section 18, Berne Twp., Fairfield Co. Lewis K. Cook. and Franklin, Jackson Co. A. L. Pierstorff.
339. *Festuca shortii* Kunth. Short's Fescue-grass. Circleville Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
355. *Poa autumnalis* Muhl. Flexuous Spear-grass. Cadiz Twp., Harrison Co. Edward S. Thomas.
394. *Sporobolus clandestinus* (Spreng.) Hitchc. Rough Rush-grass. Along B. & O. R. R. track near New Vienna, Clinton Co. Katie M. Roads.
- 403.1. *Agrostis palustris* Huds. Creeping Bent-grass. Sugar Run, Ross Co. Gordon S. Crowl.
478. *Panicum leibergii* (Vasey) Scribn. Leiberg's Panic-grass. Deer Creek Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
488. *Panicum lindheimeri* Nash. Lindheimer's Panic-grass. Deer Creek Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
493. *Panicum meridionale* Ashe. Matting Panic-grass. Liberty Twp., Wood Co. R. E. Shanks.
536. *Allium cepa* L. Common Onion. On railway embankment. Columbus, Franklin Co. John H. Schaffner.
- 537.1. *Allium sativum* L. Garlic. Common along the Danville Road near Hillsboro, Highland Co. Katie M. Roads.
552. *Stenanthium robustum* Wats. Stout *Stenanthium*. On steep hillside, open field. Gallia Co. Leslie L. Pontius and Floyd Bartley.
- 597.2. *Juncus vaseyi* Engelm. Vasey's Rush. In pastured woods. Perry Twp., Shelby Co. R. E. Shanks.
603. *Juncus articulatus* L. Jointed Rush. Mentor, Lake Co. Don M. Brown.
606. *Juncus brachycarpus* Engelm. Short-fuited Rush. Plain Twp., Wood Co. R. E. Shanks.
614. *Xyris torta* Smith. Slender Yellow-eyed-grass. In a bog, Madison Twp., Scioto Co. Floyd B. Chapman.
616. *Manfreda virginica* (L.) Salisb. False Aloe. About 100 plants in southwestern New Market Twp., Highland Co. Katie M. Roads.
669. *Tipularia unifolia* (Muhl.) B. S. P. Crane-fly Orchis. Waterloo Forest, Athens Co. Walter P. Porter.
678. *Magnolia acuminata* L. Cucumber Magnolia. Perry Co. Edward S. Thomas.
685. *Ranunculus pennsylvanicus* L. f. Bristly Buttercup. Urbana Raised Bog. Urbana Twp., Champaign Co. Margaret B. Church.
- 725.1. *Thalictrum caulophylloides* Small. Cohosh Meadow-rue. Clifton Gorge, Greene Co. Leslie L. Pontius and Floyd Bartley.
745. *Papaver rhoeas* L. Field Poppy. Hundreds in the tall grass along the road half way between New Antioch and New Vienna, Clinton Co. Katie M. Roads.
762. *Berteroa incana* (L.) DC. Hoary *Berteroa*. Cadiz, Harrison Co. V. G. Applegate.
812. *Arabis virginica* (L.) Trel. Virginia Rock-cress. Athens Twp., Athens Co. Walter P. Porter and P. S. Wamsley.
830. *Leavenworthia uniflora* (Mx.) Britt. Michaux's *Leavenworthia*. Lynx, Adams Co. Floyd B. Chapman.
855. *Erodium cicutarium* (L.) L'Her. Stork's-bill. Plentiful in fields. Buchtel, Athens Co. Len. Stephenson.

884. *Polygala cruciata* L. Cross-leaf Milkwort. Liberty Twp., Wood Co. R. E. Shanks.
885. *Polygala ambigua* Nutt. Loose-spiked Milkwort. Mew Market Twp., Highland Co. Katie M. Roads.
896. *Tithymalus lathyris* (L.) Hill. Caper Spurge. Spontaneous at Grandview, Franklin Co. Wendell Paddock.
914. *Callitriche heterophylla* Pursh. Larger Water-starwort. Near Zaleski, Vinton Co. Walter P. Porter.
924. *Sida hermaphrodita* (L.) Rusby. Tall Sida. Along Ohio River. Green Twp., Scioto Co. Conrad Roth and Floyd B. Chapman.
- 976.1. *Viola primulifolia* L. Primrose-leaf Violet. Madison Twp., Scioto Co. Floyd B. Chapman and Conrad Roth.
977. *Viola lanceolata* L. Lanceleaf Violet. In a bog, Madison Twp., Scioto Co. Floyd B. Chapman and Conrad Roth.
992. *Sagina procumbens* L. Procumbent Pearlwort. Athens, Athens Co. Walter P. Porter.
1024. *Silene rotundifolia* Nutt. Roundleaf Catchfly. Chimney Rocks, Pike Co. Gordon S. Crowl.
1147. *Fragaria vesca* L. European Wood Strawberry. Established accidentally in the edge of a large flower bed. Hillsboro, Highland Co. Katie M. Roads.
- 1155.1. *Rubus argutus* Link. Tall Blackberry. Coleraine Twp., Ross Co. Donald McBeth.
1337. *Heuchera villosa* Mx. Hairy Alum-root. Perry Twp., Lawrence Co. F. B. Chapman and Conrad Roth.
1477. *Salix candida* Fl. Hoary Willow. In a swamp near Hudson, Portage Co. Floyd Bartley and Leslie L. Pontius.
1497. *Grossularia reclinata* (L.) Mill. Garden Gooseberry. Along the road. Liberty Twp., Highland Co. Katie M. Roads.
1526. *Cucurbita lagenaria* L. Bottle Gourd. A large patch in a pasture lot near New Vienna, Clinton Co. Katie M. Roads.
1545. *Xolisma ligustrina* (L.) Britton. Xolisma. Springfield Twp., Gallia Co. Clyde H. Jones.
1553. *Chimaphila umbellata* (L.) Nutt. Pipsissewa. Liberty Twp., Wood Co. R. E. Shanks.
1592. *Convolvulus fraterniflorus* Mack. & Bush. Short-stalked Bindweed. Near New Vienna, Clinton Co. Katie M. Roads.
- 1611.1. *Buddleia davidi* Franch. Butterfly-bush. In a dense weed patch in the basement of a burned-down factory. Hillsboro, Highland Co. Katie M. Roads.
- 1613.1. *Ligustrum obtusifolium* S. & Z. Blunt-leaf Privet. Three large bushes along a small wooded stream near Blanchester, Clinton Co. Katie M. Roads.
1625. *Gentiana procera* Holm. Smaller Fringed Gentian. Greene Twp., Ross Co., and Deer Creek Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius. Also south of Rock Bridge, Hocking Co. Mrs. C. G. Landis and Mrs. Wm. Halenkamp.
- 1660.2. *Petunia hybrida* Vilm. Common Garden Petunia. Escaped in a pasture lot, Hillsboro, Highland Co. Katie M. Roads.
1756. *Utricularia gibba* L. Humped Bladderwort. Athens State Hospital Lakes, Athens Co. Walter P. Porter.
1774. *Liliospermum carolinense* (Walt.) Mack. Hairy Puccoon. Plain Twp., Wood Co. and Washington Twp., Henry Co. R. E. Shanks.
- 2076.1a. *Bidens polylepis retrorsa* Sherff. Large-bracted Tickseed. Porter Twp., Scioto Co. Conrad Roth.
- 2101.1. *Tageles patula* L. French Marigold. Along the N. & W. R. R. track. Hillsboro, Highland Co. Katie M. Roads.
- 2102.1. *Calendula officinalis* L. Pot-marigold. In a vacant lot in Hillsboro, Highland Co. Katie M. Roads.
2143. *Bellis perennis* L. European Daisy. Common in lawns and lawn-extensions. Wooster, Wayne Co. John H. Schaffner.
2189. *Eupatorium serotinum* Mx. Late-flowering Thoroughwort. Swamp along Black Fork Creek, Jackson Co. Floyd Bartley and Lester L. Pontius. Also Greene Twp., Scioto Co. Floyd B. Chapman and Conrad Roth.
- 2285.1. *Crepis pulchra* L. Small-flowered Hawksbeard. Along railway track, Penn Twp., Highland Co. Katie M. Roads.
2296. *Sonchus arvensis* L. Field Sow-thistle. Along railroad track near New Vienna, Clinton Co. Katie M. Roads.

# THE TEXANANUS (HOMOPTERA, CICADELLIDAE) SPECIES OF THE MAJESTUS GROUP WITH THE DESCRIPTION OF FOUR NEW SPECIES

DWIGHT M. DE LONG  
Ohio State University

*Texananus majestus* O. & B. was described as a species of *Phlepsius* by Osborn and Ball in 1897<sup>1</sup>. The male type in the Osborn collection is from Philadelphia, Pennsylvania. In 1918 Ball<sup>2</sup> described *handlirschi* from Mexican specimens which he stated was "slightly smaller and with a narrower vertex" than *majestus*. The writer has not had an opportunity to examine the types of *handlirschi* nor specimens from Mexico, but specimens from Texas compared with the Ball types have been examined through the courtesy of Dr. Beamer, and the characters used for this species in the present treatment are based upon those specimens. An examination of a large number of specimens of this group from various parts of the eastern United States indicates that there are several species which have been placed under the name *majestus*. An attempt has been made, and a key provided to separate these on the basis of the male genital structures. The female genitalia are similar in type but the males offer several diagnostic characters for the separation of these species. The male pygofer each bear a distinct apical lobe which varies in different species. The male plates and styles vary in length, curvature and width. The aedeagus is composed of a ventral and dorsal portion, the dorsal portion bearing a dorso-anterior lobe which is distinctive in certain species and the ventral portion furnishes characters especially in the comparative length, width, and the structure of the branches or forked apex.

## KEY TO MALES OF SPECIES OF THE MAJESTUS GROUP

1. Apex of each fork of ventral portion of aedeagus bifid..... *dicentrus*
- 1'. Apex of each fork of ventral portion of aedeagus pointed, not bifid..... 2
- 2(1). Ventral aedeagus portion sharply bent ventrally and produced for more than one-third its length at apex..... *borrori*
- 2'. Ventral portion of aedeagus with the apical portion not sharply bent ventrally or bent portion very short..... 3
- 3(2'). Dorso-anterior lobe of dorsal portion of aedeagus broadened apically, constricted at base. Apical pygofer lobe broadly rounded, as broad as long, constricted at base..... *bullatus*
- 3'. Dorso-anterior lobe of dorsal portion of aedeagus narrowed at apex, not constricted basally. Apical pygofer lobe elongate or short, not constricted at base..... 4
- 4(3'). Apical pygofer lobe appearing short in lateral view, bent inwardly, not constricted basally, Apical branches of ventral aedeagus slender, elongate, in lateral view appearing bent twice..... *caducus*
- 4'. Apical pygofer lobes elongate, ovate, constricted at base. Apical branches of ventral aedeagus short, thick and curved ventrally..... 5
- 5(4'). Dorso-anterior lobe of dorsal aedeagus short, gradually broadened to base by an anterior sloping margin which extends to the basal portion of dorsal aedeagus..... *majestus*
- 5'. Dorso-anterior lobe of dorsal aedeagus long, rather narrow. Anterior and posterior margins almost parallel, scarcely widened basally, anterior margin not sloping to basal portion of dorsal aedeagus..... *handlirschi*

<sup>1</sup>Proc. Iowa Acad. Sci. 4: 229, 1897.

<sup>2</sup>Ann. Ent. Soc. Amer. 11: 383, 1918.

**Texananus majestus (O. & B.)**

*P. majestus* (O. & B.). Proc. Ia. Acad. Sci. 4: 229, 1897.

Male pygofers with an elongate ovate apical lobe which is constricted at base. Ventral portion of aedeagus cleft at apex forming two processes which are tapered and curved ventrally for a short distance at tip. Dorsal portion of aedeagus with a long slender apical process which curves dorsally and extends almost to dorsal wall of pygofer. A basal lobe is shorter, pointed on caudal margin and gradually broadened to base by the sloping anterior margin which reaches base of dorsal portion. The apical two-thirds of styles almost parallel margined, scarcely notched before outwardly bent, blunt apices. Plates gradually narrowed to bluntly pointed apices.

Type locality Philadelphia, Pennsylvania.

**Texananus handlirschi (Ball)**

*P. handlirschi* Ball. Anns. Ent. Soc. Amer. 11: 383, 1918.

Male pygofer lobe elongate, ovate, proportionally broader than in *majestus*. Ventral portion of aedeagus with apical processes thicker than *majestus*, curved ventrally. Dorsally portion of aedeagus similar to *majestus* but with dorso anterior lobe longer, more narrowed, scarcely widened basally, styles distinctly notched and narrowed on outer margins near apex.

Type locality Omilteme, Mexico.

This species appears to be very similar to *majestus* in form and is more difficult to separate from it than the other species here described.

**Texananus dicentrus n. sp.**

Resembling *majestus* in form and coloration but with each terminus of forked aedeagus bifid at apex. Length male 8.5 mm.

Vertex angularly produced, three fifths as long at middle as width between eyes.

Color: Vertex with a pair of conspicuous spots just above apex. Transverse band between eyes interrupted at middle forming a right triangular spot on either side, with the base along median line. Pronotum with dark median vermiculate markings just back of vertex.

Genitalia: Male plates long, narrowed to bluntly rounded apices. Pygofers shorter than plates, the caudal lobe elongate and narrow. The ventral portion of the aedeagus is forked for about one-fourth of its length at apex and each branch is conspicuously bifid at apex bearing a prominent dorsal and a ventral tooth. The dorsal portion of the aedeagus composed of a long slender process which curves caudally then dorsally almost to dorsal wall of pygofer and a shorter dorsal process arising at the base and tapered to a blunt apex.

Holotype male collected at Fern Cliff, Illinois, by the author and Dr. C. O. Mohr, August 3, 1934, in the Illinois Natural History Survey Collection. This species can be distinguished from all others of this group by the bifid apices of the branched processes of the ventral portion of the aedeagus.

***Texananus bullatus* n. sp.**

Resembling *majestus* in form and coloration but with male plates shorter than pygofer and convexly rounded and with basal lobe of dorsal portion of aedeagus broadened. Length, male 9 mm.; female 10 mm.

Vertex rather broadly, bluntly produced, more than half as long as basal width between eyes.

Color: Vertex with a pair of dark points above apex and a broad straight interrupted dark band between the eyes. Pronotum rather heavily mottled with brown.

Genitalia: Female last ventral segment rather deeply broadly emarginate either side of a pair of approximate produced median teeth separated by a deep narrow incision extending half way to the base. Male plates shorter than pygofer and almost half as broad as long. Ventral portion of aedeagus cleft for a very short distance at apex forming a pair of blunt teeth which are slightly curved ventrally. Dorsal portion of aedeagus with a long slender process curving caudally then dorsally from which arises a dorsal process at base which is rather broad forming a rounded lobe. The caudal process of the pygofer is short and broad, and broadly rounded.

Holotype male and allotype female from Jemez Springs, New Mexico, collected June 15, 1919, in the author's collection.

***Texananus borrori* n. sp.**

Resembling *majestus* in form and coloration but with bent terminal processes of aedeagus more than one third as long as basal portion and terminal lobe of pygofer longer. Length 9.5 mm.

Vertex broadly bluntly produced, almost twice as wide between eyes as median length.

Color: Dark points on vertex above apex, faint. Transverse band dark, broad, interrupted at middle and each portion broadened at either end. The end next either eye bifid. Pronotum with the darker markings on anterior half.

Genitalia: Female last ventral segment with prominent rounded lateral angles between which the posterior margin is concavely rounded either side of a rather long, sharp, pointed tooth produced on each side of a U-shaped notch which extends half way to the base of segment.

Male plates long and slender about as long as pygofer which bear a long, rather broad caudal lobe. Ventral portion of pygofer short and robust. The apical third bent abruptly ventrally, cleft and forming two long apical, widely separated spines. The dorsal portion with a long slender curved ventral process from which arises an elongate, broader dorsal process at the base.

Holotype male and paratype male, Bellefontaine, Ohio (D. J. Borror) and a female allotype from Woodruff, Wisconsin, Sept. 3, 1916 (DeLong) in author's collection; a paratype male, from Western Springs, Illinois, collected by G. T. Reigel, August 16, 1935, in the Illinois Natural History Survey collection and one male paratype Le Seuer Co., Minnesota, July 28, 1922. (W. E. Hoffman) in the University of Minnesota collection.



I take pleasure in dedicating this species to Dr. Donald J. Borror who has collected many interesting species of leafhoppers including the holotype specimen of this species.

***Texananus caducus* n. sp.**

Resembling *majestus* in form and coloration but with apical lobe of pygofer short, blunt and not indented dorsally or ventrally at base. Length, male 8 mm.; female 9–9.5 mm.

Vertex broadly bluntly produced, more than half as long at middle as basal width between the eyes.

Color: Vertex with the two small brown spots above apex. The transverse band on disc decidedly interrupted at middle forming a short band either side. The end next each eye is widely bifurcate, the middle portion is narrowed and the portion next the middle line is greatly enlarged caudally. Pronotum heavily infuscated on anterior margin.

Genitalia: Female last ventral segment scarcely concave between lateral angles and a slightly produced blunt tooth either side of a rather narrow U-shaped notch reaching one third the distance to the base.

Male plates long, tapered to rather narrow, rounded apices exceeding pygofer in length. Pygofer with very short rounded caudal lobes which are not constricted or notched at base. Ventral portion of aedeagus long, apical fourth bent abruptly ventrally and cleft, forming two apical processes which are more slender than basal aedeagus body and are separated. Dorsal portion with a ventral, long, curved, slender process from the base of which arises a short broader dorsal process.

Holotype male, allotype female. Ada, Oklahoma, July 16, 1937, collected by Standish and Kaiser.

Male and female paratypes, Lebanon, Okla., Hinton, Okla., and Grant, Okla., July, 1937; Clarksville, Tennessee, August, 1917 (DeLong); High Knob, Ill., October, 1934; Anvil Rock, October, 1934; Havana, Ill., Nov., 1912, and August, 1934; and Fern Cliff, Ill., August, 1934 (Frison, Ross, Mohr and DeLong).

Holotype allotype and paratypes in the author's collection. Paratypes in the Illinois Natural History Survey collection and the collection of the Oklahoma A. & M. College.

---

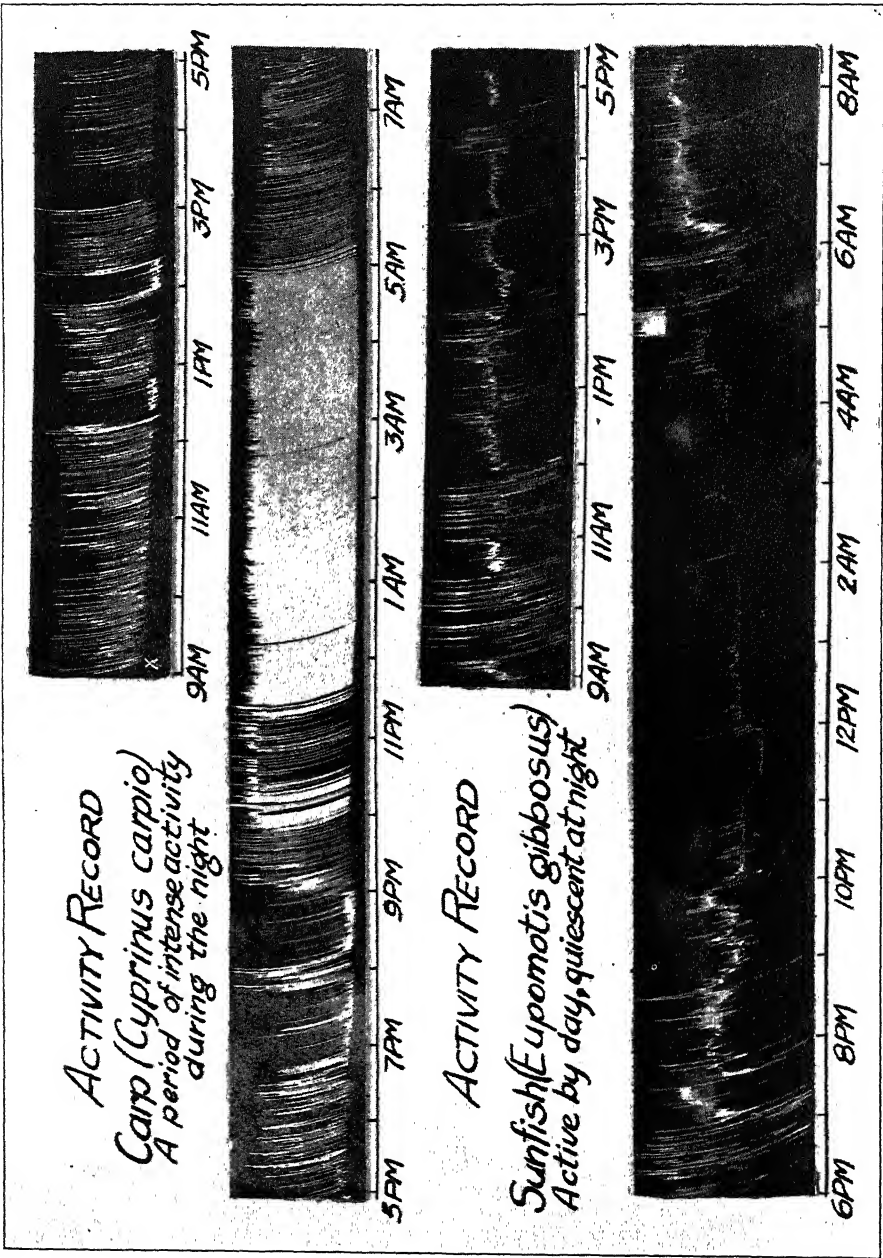
**Electromagnetism**

A new book dealing with the theory of electromagnetism on an intermediate level which should prove very useful to many teachers in Cullwick's "The Fundamentals of Electromagnetism." The material is contained in five chapters of which the first is devoted to the electrostatic field and the electric current; the second chapter is given over to the magnetic field and electromagnetic induction; chapter three treats the magnetic field and the electric current; chapter four deals with ferromagnetism and the final and fifth chapter contains a discussion of electromagnetic waves and the vector potential of the electric current.

The book is written in a most readable manner and the material is discussed in an interesting, if in many cases unorthodox, manner. The book is well worth owning and should prove useful as a text in intermediate courses on the subject for technical and arts students.—*H. H. Nielsen.*

**The Fundamentals of Electromagnetism**, by E. Geoffrey Cullwick. xxvi+352 pp. New York, the Macmillan Co., 1939. \$4.50.





# THE OHIO JOURNAL OF SCIENCE

---

VOL. XXXIX

SEPTEMBER, 1939

No. 5

---

## STUDIES ON REARING THE OPOSSUM (DIDELPHYS VIRGINIANA)<sup>1</sup>

G. E. COGHILL,  
Gainesville, Florida

Scientific reports should in a sense be news. That is, they should be made promptly when the work is completed. On the other hand some things always have interest, and time does not detract from their scientific value, which may only appear after perhaps years have elapsed. Such, I believe, is the case with this report, at least with reference to certain parts which relate to records of many years standing.

During my professorship in Denison University, the Ohio Academy of Science gave me fifty dollars from the McMillan fund to defray the expenses of studying the life history of the opossum, particularly to experiment on breeding and rearing the animals in confinement. The following year it added twenty-five dollars to the grant for me to continue the work, but, while I reported my results in a paper before the Academy, I never published my findings because they seemed too incomplete at the time, and only last season did I have an opportunity to go on with the study. In making my report before the Academy I used lantern slides made from photographs, and, inasmuch as they represent phases of the life history that I have never seen illustrated photographically, some of them are reproduced in this paper.

The opossums were confined in pens—a large one to accommodate a number of animals, and small ones, sixteen feet square, for individual females. These pens were constructed of poultry netting surmounted by strips of "valley" tin. The lower edge of the wire was buried in the ground and the upper edge was made fast to the tin by means of wire loops. The tin was supported above by strong wire bound to it with wire loops.

---

<sup>1</sup>This work was aided by a grant from the Josiah Macy, Jr., Foundation.

This wire and tin construction was nailed to posts, which were on the outside so that the animals could not use them for climbing. This proved to be a satisfactory fence. That is, it

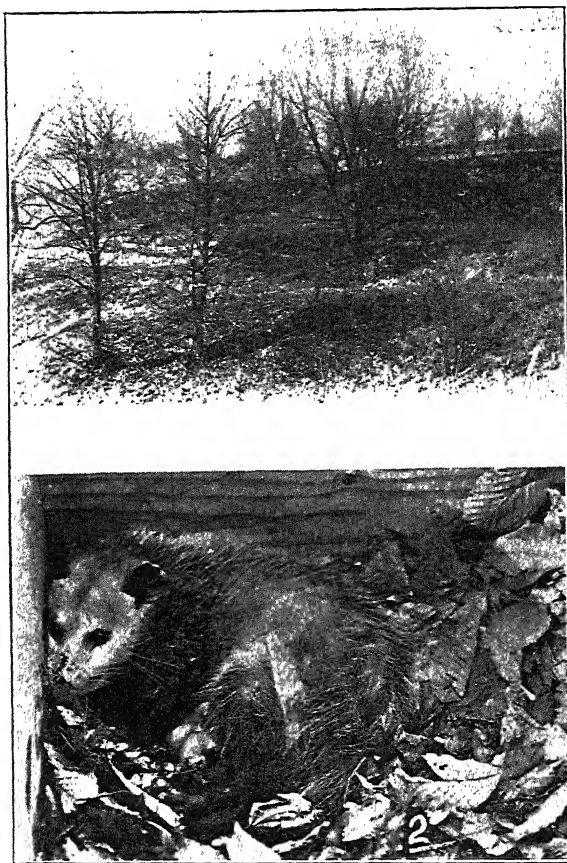


Fig. 1. The larger pen used for opossums in Granville. The fence is in view to the left of center. This shows also the natural environ preserved for the animals.

Fig. 2. A photograph of a mother opossum in the nest box from which the lid had been removed with very little disturbance of the animal. The young can be seen with their bodies outside the pouch while they still hold to the teats. The leaves of the nest were gathered and arranged in the box by the mother as they are seen in the picture.

confined the animals within the pens but it did not keep wild animals out, for they could gain entrance by climbing the posts. Pens constructed in this way, while confining the animals, gave them a close approximation to their natural habitat, in the way

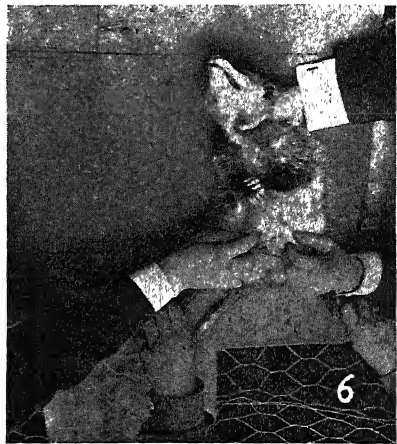
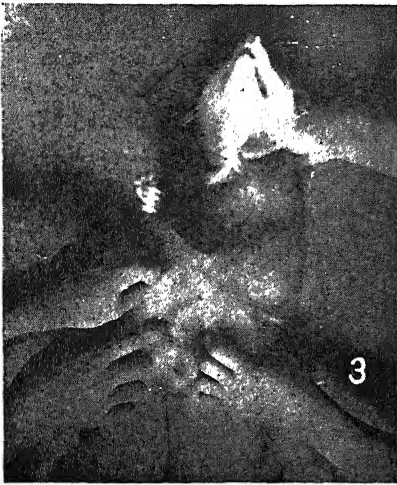


Fig. 3. A photograph of the pouch of the opossum with young of the first day. The pouch is lined with a dense coat of hair, in which the young opossums are barely visible.

Fig. 4. Photograph of the pouch and young at three weeks. The mother was held in position on the lid of the nest box for the picture.

Fig. 5. The mother and young at four weeks photographed on the lid of the nest box.

Fig. 6. The young at nine weeks photographed in the pouch.

of the fresh air of the woods and considerable freedom to move about (figure 1).

In the pens were movable nest boxes, twenty-four inches square and twelve inches high on one side and eighteen inches on the opposite side, and the roof was removable for inspection of the animals (figure 2). A door of suitable size was provided for the animals and the houses were constructed with a substantial floor to protect against moisture. In these pens and nest boxes the animals lived in a healthy condition, and young were born and reared.

In one instance copulation was observed by a competent attendant, and the gestation period was proved to be twelve days. The litter resulting from this insemination was photographed in the pouch on the first day (figure 3). This litter was photographed also at three weeks (figure 4), at four weeks (figure 5), at nine weeks (figure 6), and at ten weeks (figure 7). The young adult animal that grew up in confinement was photographed in its natural environment of the large pen (figure 8). This animal exhibited a form of nest building that, so far as I know, has never been described excepting in my report before the Academy. On an inspection tour of the pens on an autumn day I was unable to find the specimen until I noticed a conical pile of leaves which seemed too regular in form and structure to be accidental. On inspection by carefully moving the uppermost leaves to one side I discovered my opossum, which was in perfect concealment in an otherwise relatively open and exposed place. I replaced the leaves as nearly as possible as I had found them, and called the photographer. The accompanying photographs are made from lantern slides I used in my report to the Academy over twenty-five years ago (figures 9 and 10).

The purpose of my earlier work on rearing the opossum in confinement was primarily for the study of the nervous system. In my study of the cranial nerves of *Amblystoma* (1) I had found that it was possible, in specimens of appropriate age, to select a stage in which the eleventh cranial nerve is medullated when the other components of vagus ganglion through which it passes are not medullated, and by that means of differentiation I demonstrated for the first time that this nerve was actually the spinal accessory of higher vertebrates. The relatively precocious development of the eleventh nerve was the key to its identification. Therefore, it occurred to me, the relatively precocious development of the visceral sensory and motor sys-



Fig. 7. In this picture the young, photographed at ten weeks, snugly fill the pouch.

Fig. 8. An opossum thirteen months old which was reared in the pen illustrated in Fig. 1. The six-inch measure gives an idea of the size. Observe the cavern in the rocks and the natural environment.

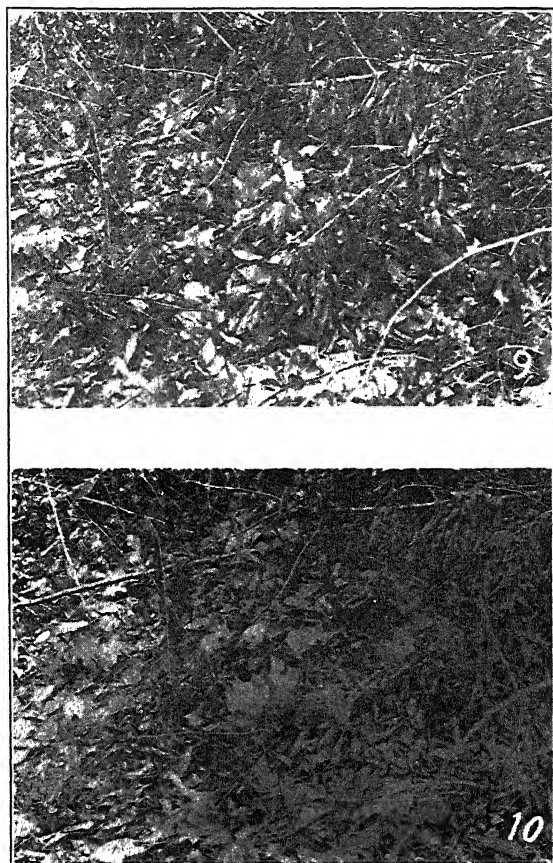


tem in adaptation to early feeding in the opossum should enable one to differentiate these components within the brain. And with this as a point of departure I hoped to study the development of the nervous system and, possible, the development of behavior. However, I was then engaged in studies on the correlation of structure and function of the nervous system of *Amblystoma* in development, which demanded more and more of my time; and in 1913 I left the State of Ohio and had to abandon the project of rearing opossums.

Meanwhile the interest that has developed in the opossum since my experiments on rearing the animal has proved that they were timely. Since that time Hartman (2) has published his excellent studies on the development of the opossum and on the behavior of the young. He discovered that the young actually crawl into the pouch, and was first to describe the process. He was very emphatic, however, in his opinion that the opossum would not breed, at least in a satisfactory way, in confinement, and that development would not be normal if it did. Following Hartman, Rogers (3) studied the physiology of the cerebral cortex, Gray and Turner (4) studied especially the motor cortex, Langworthy and Weed (5) and Langworthy (6) investigated the brain physiologically and structurally. Also, more recently, Larsell, McCrady and Zimmerman (7) have reported on the structural development of the ear of the opossum, both with regard to the auditory and vestibular functions.

Following my residence in Ohio I had no opportunity to continue the work on the opossum till I came to Florida, where thanks to the Josiah Macy, Jr., Foundation, I was able to build pens and procure specimens for the breeding season of 1938. Again I used box-houses in the open and individual pens, but of a somewhat different design from those I used in Ohio. My housing is on the apartment plan, and the houses contain four apartments designed to accommodate one specimen each. Two houses, with the separate runways between them, form a unit. The houses are thirty inches by forty-eight inches, and the apartments, twelve inches by thirty inches, each with its hinged lid (roof) for inspection, and a door giving the animal access to the runway. The runways extend between the two houses of a unit, but are divided by a partition in the middle in such a way that the eight animals of a unit may be fed and watered at one operation. The runways are essentially tunnels made with two six inch boards for floor and two for roof, and frames

of wire cloth (one-half inch mesh) for the sides and partitions. The frames and boards are ten feet long, and the sections are held in place by suitable supports. At the adjacent ends the



Figs. 9 and 10. Photograph of the nest of the opossum which is shown in fig. 8 from directly above. The nest is not in view as a whole, so that its conical shape can not be recognized but only the top-central portion is in the field. Fig. 9 shows the original structure as nearly as I could reconstruct it after discovering its occupant. Fig. 10 shows the nest sufficiently opened to expose the head of the opossum slightly to right of center.

frames of wire cloth are held to the posts of the supports by a bolt in the middle so that there is considerable flexibility of the system in the vertical plane. The length of the runways is a multiple of ten feet, and by using an odd number of frames and

placing the partition in the middle of a section, the eight animals may be fed and watered by the removal of four boards of the roof. If desired the floor can be constructed of wire cloth and the runways elevated so that they can be cleaned with a hose. In feeding I have used successfully a well-known brand of dog food. This system of houses and runways is a success in that opossums bred in them and had healthy young, which were removed from the pouch and their behavior studied. Furthermore, a part of a litter may be removed from the pouch and the rest left for later observation.

Upon withdrawal from the pouch the young cling tenaciously to the teat (figure 11). Sometimes a drop of blood appears near the mouth, but I did not determine its source, whether from the mother or from the young. Immediately after removal from the pouch the young were placed in an incubator designed for the purpose. It is thirty inches long, sixteen inches wide and thirty inches high over all. In the upper part is a chamber for observation five inches high, covered with plate glass and with a door in front that swings down to the horizontal position and furnishes an arm rest. In the opening of the door is a curtain which drops over and around the wrists of the observer when he inserts his hands for manipulating the specimens. From the rear of the chamber a well, eighteen inches deep and five inches wide, extends the whole length of the incubator and is covered with fine wire screen. In the bottom of this well, attached to a removable floor, are electric lights as heating units. In each end of the well and chamber are three round windows which can be opened or closed at will for ventilation. The well, chamber and door are lined with insulating board.

In the incubator the young are placed on outing flannel in shallow dishes. The flannel is saturated with mineral oil, which soon covers the skin completely, due to the almost continual activity of the young, and prevents desiccation of the skin. The flannel, also, furnishes a fibrous surface on which the claws can take hold for the young to right themselves to an upright position and crawl. Under these conditions in the incubator the young of the first day after birth will live as long as seven hours, and those three days old as long as twelve hours, dying apparently from inanition. It is not certain that the young live longer in the incubator than they would at room temperature but they are much more active in the incubator. At room temperature they soon become cold to the touch and pale, and

are very inactive. Their reactions can not be normal when they are in a stupor from cold.

My interest in the opossum now centers, not primarily in the nervous system, for I cannot hope to do the requisite microscopic work, but in the development of its behavior. During the breeding season of 1938 I made exploratory studies

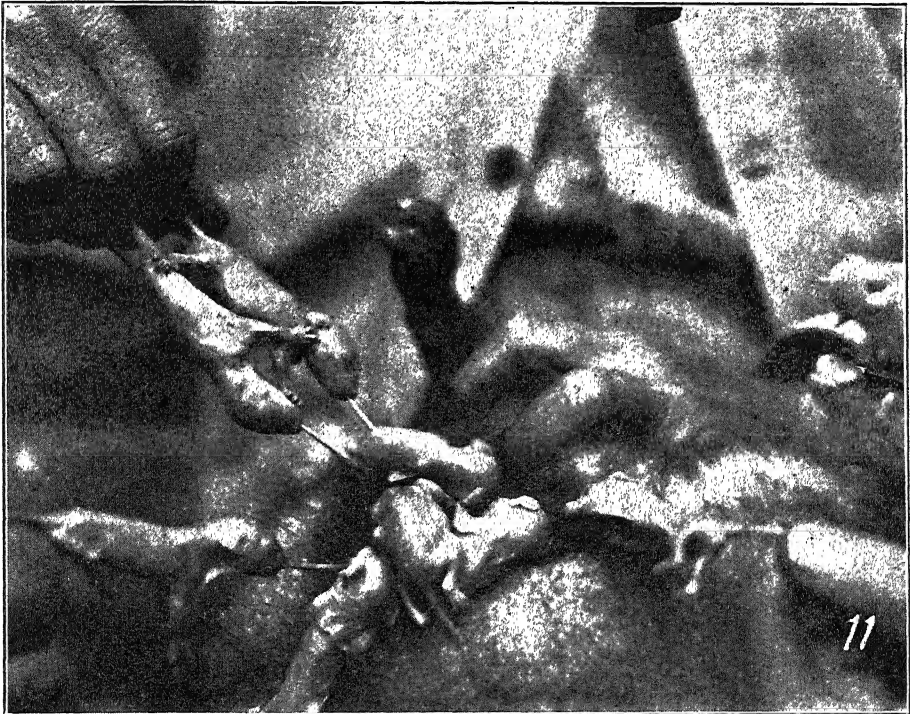


Fig. 11. A photograph of the young opossums being drawn forcibly from the mother. This photograph was given me by Mr. C. D. Bunker, Curator of the Museum of the University of Kansas, and is published with his permission.

which yielded definite results on a few points, particularly upon the movement of the legs and walking. A brief report of this work is published elsewhere (8), but it is appropriate here to give an account of it in greater detail.

The opossum at birth has the unusual ability of standing upright (righting reaction) on a suitable surface by thigmotactic response. This action has been known simply as a behavior pattern since the studies of Hartman, but only since the observa-

tions by Larsell, McCrady and Zimmerman has it been known that the vestibular system is not developed at this time. It cannot, therefore, be a factor in this response.

In this righting reaction the fore limbs and snout are the chief factors, and probably the snout is most important as a sensory organ for transmitting the tactile stimuli, for the young animal is constantly rooting deeply into the flannel or moving the snout from side to side high in the air as if searching for contact. The result of this behavior under natural conditions would be to find the teat in the pouch. Meanwhile the fore limbs are the chief effector agents in the righting reactions. The claws of the fore feet are very strong and catch upon any suitable object with which they come in contact, such as the hair of the mother or the fibers of a rough cloth. By this means the young can swing suspended from the under surface of flannel if the cloth on which it lies is gradually inverted. In this performance the claws of the hind feet participate, although at that time the hind foot barely projects beyond the contours of the body, and is perfectly immobile. The part that the hind feet play in the performance is, therefore, wholly passive, but that the fore feet actively take hold of the fabric is certain, for in the reaching movement of the fore leg and foot the flexion of the toes is plainly visible as the arm begins to withdraw. By this action of the limbs and claws in co-operation with the movements of the snout the young animal can right himself and walk. In the absence of the vestibular system this righting reaction and walking is purely thigmotactic.

Probably the most important thing about the behavior of the young opossum is the retarded development of the hind limbs relative to the fore limbs and head. When the young one is born, and for about a week thereafter, it can not move the hind limbs, in response either to external stimulation or to internal conditions (spontaneously). For this reason the behavior of the hind limbs, and their participation in the behavior of the whole animal, can be observed from the first in the born animal, whereas, in animals other than the marsupials, this phase of behavior can be studied only in the embryo. Furthermore, embryos are very fragile and require special methods and refined technique to be brought under observation and kept alive in a condition that approximates the normal. The young opossum, on the other hand, is easily accessible and is very hardy. The simple expedients of keeping it warm and

preventing the skin from drying are all the precautions necessary to insure lively behavior, and one can handle them roughly apparently without injuring them, so that one does not question whether or not the behavior is normal. By taking advantage of this condition I have been able, for instance, to prove satisfactorily to myself, that the hind limbs become co-ordinated with the fore limbs in the walking gait before they are capable of reflex action in response to stimulation on the foot. This means that there are two components of locomotion: the action of the total pattern, which establishes gait; and reflex action, which maintains the appropriate relation to surfaces. This is simply and directly seen in the young opossum whereas it would require special precaution and elaborate technique to see it in the embryos of Eutheria. In *Amblystoma*, however, I have definitely established this principle (9). That it applies to marsupials, also, is important to physiology.

In conclusion, the work that was begun over twenty-five years ago with the aid of the Ohio Academy of Science has been confirmed and supplemented by recent work. The opossum will breed in confinement if a close approximation to its normal habitat is maintained. Expensive buildings and luxurious laboratories are not necessary. They are, on the other hand, probably a hindrance rather than a help, in that they subject the animals to extremely abnormal environment. Simple nest houses and runways out of doors is all that is necessary.

For the excellent photographs of figures 1 to 10 I am greatly indebted to Mr. Howard Clark, who was a student in Denison University at the time of my earlier work in Granville. For the photograph of figure 11 I wish to thank my friend, Mr. C. D. Bunker, of the University of Kansas.

#### LITERATURE CITED

- (1) Coghill, G. E. 1902. Jour. Comp. Neurol. XII: 205-296.
- (2) Hartman, C. G. 1920. Anat. Record XIX: 251.
- (3) Rogers, F. T. 1925. Amer. Jour. Physiol. 63: 433; 1924. Jour. Comp. Neurol. 37: 265.
- (4) Gray, P. A. 1924. Jour. Comp. Neurol. 37: 221.  
Gray, P. A., and E. L. Turner. 1924. Jour. Comp. Neurol. 36: 375.
- (5) Weed, L. H., and O. R. Langworthy. 1925. Amer. Jour. Physiol. 72: 25.  
1925. Amer. Jour. Physiol. 72: 8.
- (6) Langworthy, O. R. 1925. Amer. Jour. Physiol. 74: 1. 1927. Contributions to Embryology, No. 103, Carnegie Inst. Wash. Pub., Vol. XIX, No. 380, p. 149; Contributions to Embryology, No. 104, Carnegie Inst. Wash. Pub., Vol. XIX, No. 380, p. 177.
- (7) Larsell, O., Edward McCrady, Jr., and U. A. Zimmerman. 1935. Jour. Comp. Neurol. 63: 95.
- (8) Coghill, G. E. 1938. Proc. Soc. Exp. Biol. and Med. 39: 31-35.
- (9) Coghill, G. E. 1929. Proc. Soc. Exp. Biol. and Med. 27: 74. 1929. "Anatomy and the Problems of Behavior" Cambridge University Press, p. 23.

# THE PRODUCTION OF ACCESSORY APPENDAGES AND ANTERIOR DOUBLING IN FROG EMBRYOS BY CENTRIFUGAL FORCE

C. S. THORNTON AND R. E. ELLIS

Department of Biology,  
Kenyon College, Gambier, Ohio

In looking through the literature one finds that very little work has been done on the effect of centrifugal force on the blastula of the frog or salamander. We feel that this technique may be applied with advantage to problems of amphibian experimental embryology. This belief is supported by the interesting results obtained by Banta and Gortner ('15) in centrifuging the eggs of *Rana sylvatica*. These authors found that headless monsters and tadpoles with accessory appendages were produced when eggs in the early blastopore stage were centrifuged at speeds varying from 200 times gravity to 1200 times gravity. It was in an attempt to confirm the work of Banta and Gortner and to discover whether other types of abnormalities could be produced in the frog egg by centrifugal force, that the experiments reported here were carried out.

The eggs which were used in the present experiments were of *Rana sylvatica*, and were collected in the vicinity of Gambier, Ohio, during the months of March and April, 1938. Five clusters of eggs were used, each cluster containing from 150-200 eggs. Two thirds of the eggs in each cluster were centrifuged at speeds indicated below, the remaining one third of the eggs in each cluster served as controls. The first series (cluster 1), was composed of eggs in the mid-gastrula stage and these eggs were centrifuged at 1400 r.p.m. for ten minutes. The second series (cluster 2) was composed of eggs in the late blastula stage and these were centrifuged at 1400 r.p.m. for ten minutes. The third series (cluster 3) was composed of eggs in the early blastopore stage and these were centrifuged at 1800 r.p.m. for five minutes. The fourth series (cluster 4) consisted of eggs likewise in the early blastopore stage. These were centrifuged at 2900 r.p.m. for ten minutes. Eggs in the fifth series (cluster 5) were in the late blastula stage and these also were centrifuged at 2900 r.p.m. for ten minutes.

The eggs in series I, which were in the mid-gastrula stage at the time of centrifuging, developed normally. A large per-

centage of the eggs in series II-IV, which were either in the late blastula or early gastrula stages, developed accessory appendages or anterior doubling. It is evident from these results that the egg of *Rana sylvatica* has become resistant to centrifugal force by the mid-gastrula stage. Only those eggs which were in stage 10 of Pollister and Moore ('37) ever developed abnormalities. The eggs of series V gave the highest percentage of abnormalities and it is interesting to note that this was the only series in which anterior doubling occurred. Very few eggs were killed by the centrifugal force. In all 60% of the eggs developed accessory appendages. In series V, 50% of the eggs gave rise to double monsters.

The accessory appendages which were produced were in all cases tail-like in appearance. These appendages are designated as tails although no true myotomes develop in them. Histologically these structures resemble the tail fin of a normal amphibian tail for they are composed largely of epidermis, dermis and connective tissue. These accessory tails may occur at any point on the body of the tadpole. The most common location is on the belly, but several have been observed on the dorsal side of the body just lateral to the normal tail fin. These accessory tails vary in size from tiny projections to the large structures shown in figure 1.

Banta and Gortner reported that several of the animals in their experiments which had accessory tails also had spina bifida. They found in these animals that each half of the unclosed neural groove in the posterior region of the embryo produced a tail. Similar cases have been found in our experiments and seem to be the result of the spina bifida condition. However, these cases are few in number.

In the animals possessing secondary tails on the dorsal side of the body, many cases are found in which the accessory tail fin makes a junction with the normal tail fin. An examination of the history of these cases shows that in the neurula stage a secondary and abortive neural fold had been formed which made junction with the posterior region of the primary neural folds. The neural groove later closed normally leaving a small section of neural fold tissue still connected with the neural tube and projecting at an angle from it. This section of neural fold material produced the accessory tail. This result may be correlated with the findings of Mangold ('32A) who induced the formation of a secondary tail in *Triton* by transplanting to an



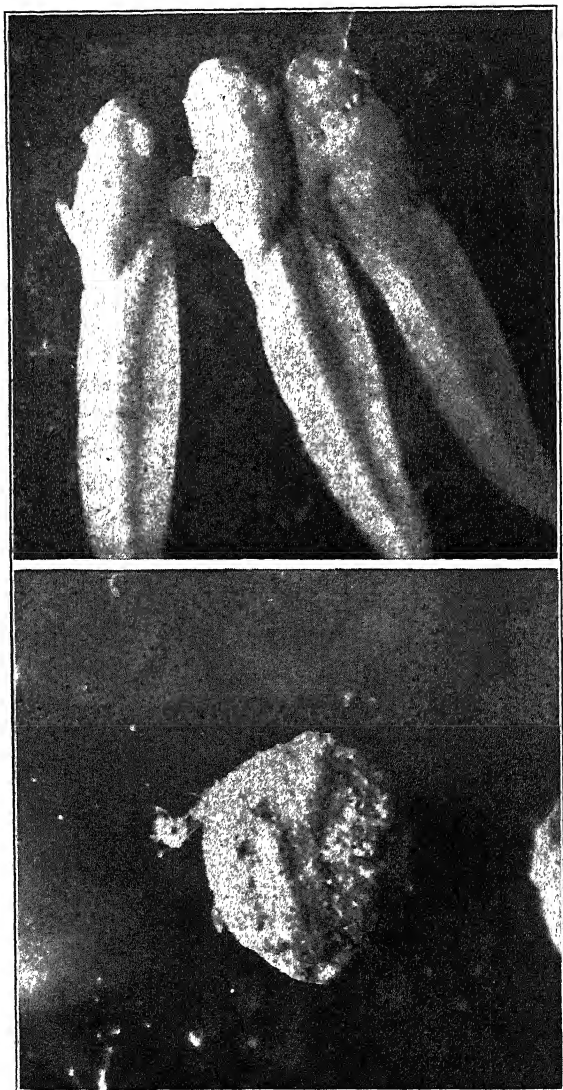


Fig. 1 (upper). Frog tadpoles showing position and appearance of accessory tail-like appendages.

Fig. 2 (lower). Photomicrograph of a frog embryo showing two neural grooves in the anterior region. This embryo died before fixation.

early gastrula the caudal quarter of the medullary plate of a Triton neurula.

The accessory tails occurring on the ventral region of the body are harder to account for, but probably arose through the transference of a portion of the tail-forming material to that region by the centrifugal force, as has been suggested by Banta and Gortner ('15). It is interesting to note that sections show neural tube-like structures at the proximal ends of these secondary tails.

In series V anterior doubling occurred in 50% of the cases. Figure 2 is a photomicrograph of an egg showing such anterior doubling. These double monsters all died in early embryonic stages, with the exception of one case which developed into a tadpole with incomplete anterior doubling. Penners and Schleip ('28A, -'28B) have obtained similar cases of anterior doubling in the frog by inverting the fertilized egg and forcing it to develop in this position. They found that in many cases the developing blastocoel was displaced, the pressure within it causing the cells which formed its walls to present an obstacle on which the blastopore lip became split. Much the same phenomenon appears to have occurred in the present experiments but due to centrifugal force. The centrifugal force acting in the blastula stage seems to have caused a displacement of the blastocoel in such a way that the dorsal roof of the blastocoel forms a wedge upon which the invaginating dorsal lip becomes split. Each portion of the dorsal lip may then give rise to as much of a neural groove as it is capable. In the experiments reported here the splitting evidently occurred in the anterior region of the embryo and anterior doubling was thus produced. Further work on this problem is in progress.

#### LITERATURE CITED

- Banta, A. M., and R. A. Gortner. 1915. Accessory appendages and other abnormalities produced in amphibian larvae through the action of centrifugal force. *J. Exp. Zool.*, vol. 18, pp. 433-451.
- Mangold, O. 1932A. Autonome und komplementäre Inductionen bei Amphibien. *Naturwissenschaften*, Bd. 20, S. 371-275.
- Penners, A., and W. Schleip. 1928A. Die Entwicklung der Schütze'schen Doppelbildungen aus dem Ei von *Rana fusca*. Teil I-IV. *Zeitschr. f. wiss. Zool.*, Bd., 130, S. 307-454.
- 1928B. Die Entwicklung der Schütze'schen Doppelbildungen aus dem Ei von *Rana fusca*. Teil V-VI. *Zeitschr. f. wiss. Zool.*, Bd. 131, S. 1-156.
- Pollister, A. W., and J. A. Moore. 1937. Tables for the normal development of *Rana sylvatica*. *Anat. Rec.*, vol. 68, pp. 489-496.

# THE GROWTH OF STEREUM GAUSAPATUM FRIES IN RELATION TO TEMPERATURE AND ACIDITY<sup>1</sup>

J. ARTHUR HERRICK,  
Kent State University

The recent discovery of the importance of *Stereum gausapatum* Fries as a major cause of heartrot of oaks (Davidson, 1934) served as a stimulus for a study of its general biology. The writer has attempted such an investigation and this paper represents a portion of that study.<sup>2</sup>

## TEMPERATURE

The relation of the growth of *S. gausapatum* to temperature has been previously investigated. Humphrey and Siggers (1933) using temperatures from 12° C. to 40° C., report 24° C. as the optimum temperature, and 38° C. as inhibiting growth. Considerable growth took place at 12° C. *S. spadiceum*, which Burt (1920) lists as a synonym of *S. gausapatum*, was studied by Cartwright and Findlay (1934). They grew the fungus at temperatures of 5° C. to 30° C. The optimum temperature employed was 25° C. Growth was not completely inhibited at either extreme.

In the present investigation the effect of temperature on growth rate was investigated by growing the fungus at various constant temperatures ranging from 5° C. to 35° C. with 5° intervals.

About 20 cc. of potato dextrose agar was poured into each of 70 Petri plates and inoculated at one edge with a small piece of mycelium taken from the edge of a vigorously growing cul-

---

<sup>1</sup>This paper is a revision of a portion of a thesis submitted to the faculty of The Ohio State University as partial fulfillment of the requirements for the degree of Doctor of Philosophy. The temperature studies were carried on at The Ohio Agricultural Experiment Station and the acidity studies at The Ohio State University.

The writer is indebted to the Department of Entomology, Ohio Agricultural Experiment Station for the use of their constant temperature chambers and to the Department of Botany and Plant Pathology, of the same institution for the use of various facilities. To Dr. W. G. Stover and other members of the Department of Botany, Ohio State University, the writer is grateful for various suggestions and criticisms.

<sup>2</sup>Two other portions of this study have recently been accepted for publication and should appear in the near future. The papers are as follows: (1) Growth and Variability of *Stereum gausapatum* Fries in Culture. To appear in *Phytopathology*. (2) A Microscopical Study of the Mycelium of *Stereum gausapatum* Fries. To appear in *Transactions of the American Microscopical Society*.

ture of a single spore isolate. In order to reduce evaporation each plate was sealed with nurseryman's tape. The cultures were kept at room temperature for 15 hours, and then ten cultures were placed in each of the various constant temperature chambers.

After six days the radius of the mycelial growth in each plate was measured in millimeters. The average growth of the ten mycelia grown at each temperature is shown in Table I.

The above experiment was repeated using malt agar with 28 cultures at each temperature and an incubation period of 10 days. The results of this experiment are also presented in Table I.

TABLE I

THE RELATION OF THE GROWTH RATE OF *Stereum gausapatum* TO TEMPERATURE AS DETERMINED BY RADIAL GROWTH OF MYCELIA AT VARIOUS CONSTANT TEMPERATURES

TEMPERATURE IN C.	5°	10°	15°	20°	25°	30°	35°
Average radial growth in mm. on potato dextrose agar in six days.....	1	3.2	5.3	27.3	44.2	32.7	2.8
Average radial growth in mm. on malt agar in ten days.....	2	10	14.4	46	73.5	66	6.5

Growth at 5° C. was very slight and probably would have been completely inhibited at some temperature between 0° C. and 5° C. The greatest growth occurred at 25° C. At 35° C. growth was very irregular and abnormal in appearance. If higher temperatures had been tried growth would probably have been inhibited at about 38° C., as reported by Humphrey and Siggers (1933).

#### ACIDITY

Various researches (Wolpert, 1924; Zeller, Schmitz and Duggar, 1919) have shown that many wood-destroying fungi grow best on an acid medium. Cartwright and Findlay (1934), Humphrey and Siggers (1933) and Bergenthal (1933) have all cultured this fungus on media which were acid in reaction, but there has been no work reported in which the relation of acidity to growth was investigated.

The relation of acidity to the growth rate of *S. gausapatum* has been studied by growing the fungus on potato dextrose agar having a series of pH values. One hundred fifty cc. of freshly

TABLE II

MYCELIAL GROWTH OF *Stereum gausapatum* ON POTATO DEXTROSE AGAR, HAVING DIFFERENT H-ION CONCENTRATIONS, AS DETERMINED BY RADIAL GROWTH OVER A PERIOD OF FIVE DAYS

pH Value	Number of Mycelia Measured	Minimum Radius in mm.	Maximum Radius in mm.	Average Radius in mm.
8.6	36	0	0	0.0
8.4	36	0	0	0.0
8.2	36	0	0	0.0
8.0	30	0	2	0.1
7.8	30	0	6	2.3
7.6	27	14	23	18.3
7.4	32	13	19	16.0
7.2	34	15	25	20.9
7.0	35	15	24	21.0
6.8	28	12	25	20.1
6.6	30	20	25	23.0
6.4	32	20	27	24.2
6.2	27	20	27	23.7
6.0	32	18	29	25.2
5.8	32	20	29	25.5
5.6	34	24	35	27.5
5.4	33	24	35	27.5
5.2	36	22	31	27.3
5.0	36	25	34	27.7
4.8	32	25	32	28.5
4.6	36	20	35	29.6
4.4	36	24	31	27.6
4.2	36	22	31	26.6
4.0	32	20	30	25.2
3.8	36	19	25	22.5
3.6	36	19	25	22.5
3.4	36	16	22	19.0
3.2	35	13	21	16.1
3.0	36	13	18	15.2
2.8	36	9	16	13.5
2.6	35	4	10	6.9
2.4	35	0.5	3	1.3
2.2	36	0	0	0.0
2.0	36	0	0	0.0
1.8	36	0	0	0.0

prepared potato dextrose agar was poured into each of several 250 cc. Erlenmeyer flasks. The flasks of agar were autoclaved at 15 lbs. pressure for 20 minutes, and stored for a few days. Upon remelting, the agar was found to have an acidity of pH 5.2. Suitable amounts of 5% or 20% HCl and of normal NaOH

were added to the various flasks so as to adjust the media to H-ion concentrations ranging from pH 1.8 to pH 8.6 with intervals of approximately 0.2 of a pH unit. The pH of the agar was determined by means of a Hellige comparator using color disks. Immediately after adjusting the acidity nine plates were poured from each flask. The plates were uniformly inoculated at four marginal points with a small piece of mycelium from a potato dextrose agar culture of a single spore isolate. They were allowed to incubate, in darkness, at room temperature, for a period of five days. On the fifth day the radii of the mycelia were measured in millimeters. The essential data of the experiment are presented in table form (Table II).

It may be seen from the data in this table that *S. gausapatum* will grow fairly well over a wide range of H-ion concentration. The optimum pH for growth appears to be about 4.6. As the acidity increases from the optimum, the rate of growth decreases rather uniformly. Growth is inhibited at pH 2.2. In certain preliminary experiments growth was sometimes observed to occur at pH 2.2, but never at pH 2.0. As the acidity decreases from the optimum to around pH 7.6 the growth rate gradually decreases, but a sudden drop takes place from this point to pH 8.0 or higher; beyond this point growth is inhibited. In the experiment here described almost no growth occurred at pH 8.0, but as was the case at the lower pH limit, in one of the preliminary experiments, a slight growth was observed at pH 8.0 but never at pH 8.2.

The data which are reported here for *S. gausapatum* compare favorably with such data for several other wood-rot fungi which have been previously studied (Wolpert, 1924). It is not possible to find any pH value which could justly be considered as the isoelectric point.

#### SUMMARY

The heartrot fungus, *Stereum gausapatum* Fries, has been grown on potato dextrose agar and on malt agar at various constant temperatures ranging from 5° C. to 35° C. Very little growth occurred at either extreme. The greatest growth occurred at 25° C.

The effect of acidity on rate of growth has been investigated by culturing the fungus on potato dextrose agar having a series of acidities. Considerable growth occurred from pH 2.8 to pH 7.6. The optimum pH for growth was found to be about 4.6.

Growth was inhibited at pH 2.2 and at pH 8.0. No indication of an isoelectric point was found.

#### LITERATURE CITED

- Bergenthal, W. Untersuchungen zur Biologie der wichtigsten deutschen Arten der Gattung *Stereum*. Zentralbl. für Bact. Abt. 2, 89: 209-236. 1933.
- Burt, E. A. The Thelephoraceae of North America. XII. *Stereum*. Ann. Mo. Bot. Gard. 7: 81-248. 1920.
- Cartwright, K. St. G., and W. P. K. Findlay. Studies in the physiology of wood-destroying fungi. II. Temperature and rate of growth. Ann. Bot. 48: 481-495. 1934.
- Davidson, R. W. *Stereum gausapatum*, cause of heartrot of oaks. Phytopath. 24: 831-832. 1934.
- Humphrey, C. J., and P. V. Siggers. Temperature relations of wood-destroying fungi. Jour. Agr. Res. 47: 997-1008. 1933.
- Wolpert, F. S. Studies in the physiology of the fungi. XVII. The growth of certain wood-destroying fungi in relation to H-ion concentration of the media. Ann. Mo. Bot. Gard. 11: 43-97. 1924.
- Zeller, S. M., H. Schmitz and B. M. Duggar. Studies in the physiology of fungi. VII. Growth of wood destroying fungi on liquid media. Ann. Mo. Bot. Gard. 6: 137-142. 1919.

---

#### Inorganic Chemistry

This new text for a general chemistry course should be a very teachable edition. The order of topics on matter and the kinetic theory, introducing those points of physics, which, with the first discussion on strictly chemical topics, and in essentially a descriptive form, (namely, oxygen, hydrogen, water and chlorine) leads directly and rapidly into the Periodic Classification and the Atomic and Molecular Structure. Thus, electrovalent and covalent linkages follow in natural sequence. The chemistry of carbon is introduced early in the book since those "whose major lies in some field other than chemistry usually find this more interesting than the inorganic material which it replaces. The elementary ideas of organic chemistry are no more difficult than those of inorganic chemistry." The five chapters on carbon and its compounds present an excellent summary of the fundamental simple concepts of organic chemistry and of its application in everyday life. Chapter 19 is a review and summary chapter on the material of the first half of the book and is claimed to be of great aid to the students for the semester review. Then follows series of topics covering the chemistry of the non-metals and their compounds and including other physical concepts necessary to the development of the Periodic Law. Eight chapters are devoted to the metallic elements. The last chapter is "Colloids" and is so organized that it may be introduced early in a course or eliminated entirely as the case may be. Chapter 31 is headed "Transmission Elements." Since one finds no exact definition of this term in the Chapter the conclusion could probably be reached that the term should be that more commonly used, namely, "Transition Elements." The concept of the scientific method is constantly utilized. The industrial and everyday applications of chemistry are chosen so that they may be of cultural value as well as for use in the teaching of the science. Very suitable questions are included at the end of each chapter. The text does not include any extended mathematical or theoretical discussion of certain topics such as equilibrium, but the more descriptive, qualitative discussions are apt and adequate. One finds in the word equation on page 31, "nitrate" instead of "nitrite" in the products formed, and Charles' is misspelled on page 261.

On studying the book, one feels it would be a very serviceable book for general use.—*Laurence L. Quill.*

**General and Inorganic Chemistry**, by Frederick C. Irwin and G. Ray Sherwood, Wayne University. x+582 pp. Philadelphia, P. Blakiston's Son and Co., Inc. 1939.

# SOME FACTORS INFLUENCING ZOÖPLANKTON DISTRIBUTION IN THE HOCKING RIVER<sup>1</sup>

LYNN HUTCHISON

Northwestern University and Ohio University

The Hocking River is located in southeastern Ohio and is a tributary of the Ohio River into which it flows about 28 miles below Marietta, Ohio. The drainage area of the river is described by Roach (1931).

The following methods and apparatus were employed during the investigation. Sixteen sampling stations were established along the river, as indicated on a map of the Hocking River (fig. 1). Stations 1 and 2, near the source of the stream, were chosen as representative of a young and unpolluted stream. Stations 3, 4, and 5 were chosen as representative of a young stream greatly polluted by organic wastes from the city of Lancaster. Stations 8, 10, and 12 represent a stream into which organic wastes are emptied from towns smaller than Lancaster and where there is a pronounced increase in the volume of water; therefore, the degree of pollution is not as great as at Stations 3 and 4 due to a decreased amount of sewage and to the dilution of the wastes. Stations 6, 7, and 9 represent a maturing stream not appreciably affected by wastes. At Station 11 the stream is polluted with mine wastes flowing in from Sunday Creek, a sizeable tributary of the Hocking. At Station 13 a dam renders the water very sluggish, although the river has not yet taken on the characteristics of an old stream. Stations 14, 15, and 16 were chosen as representative of a comparatively old stream.

Samples of water were taken from the river at these sixteen stations at intervals of one month for a period of twelve months, starting November, 1935. Samples were taken from the river about eight feet from the edge. Twenty liters of water were dipped from the river and strained through silk bolting cloth, No. 12 mesh. The residue was preserved in 10% formaldehyde.

---

<sup>1</sup>The investigator is deeply appreciative of the guidance of Prof. F. H. Krecker of Ohio University at whose suggestion the problem was undertaken; also of the aid of Dr. William Stehr of Ohio University for checking the identification of plankton organisms, and of Dr. Orlando Park of Northwestern University for criticism. This paper embodies the chief features of a thesis submitted as one of the requirements for the Master of Arts degree at Ohio University, and is contribution No. 15 from the Department of Zoölogy.



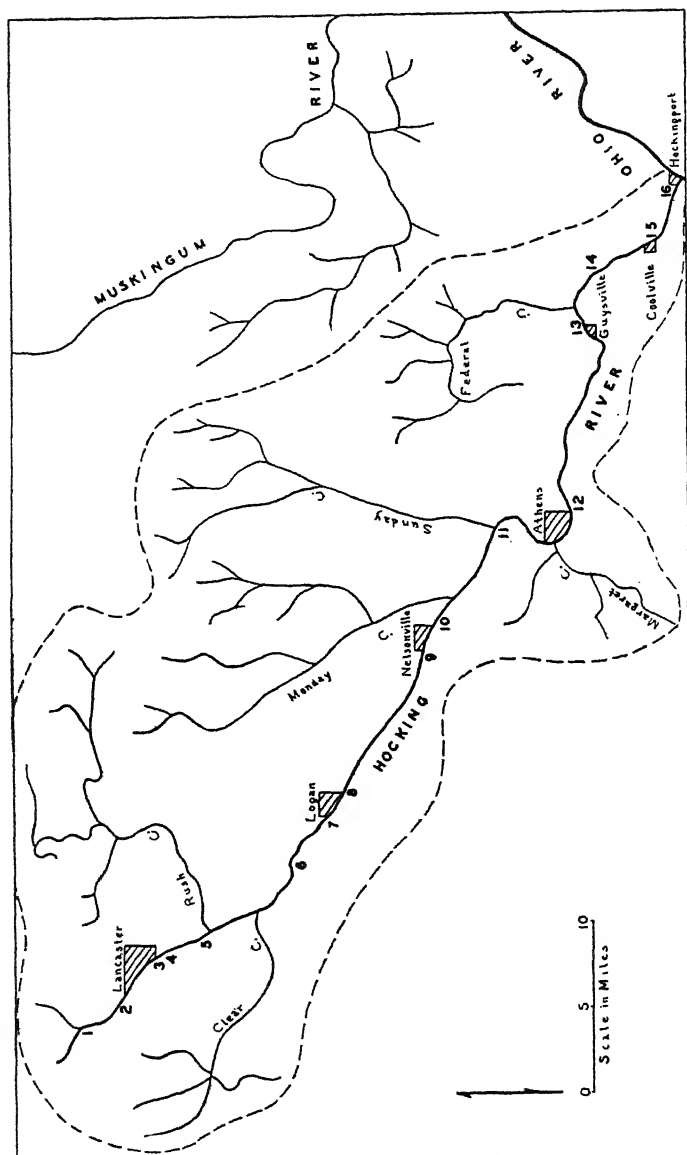


Fig. 1. Drainage area of the Hocking River. Broken line encloses the area. Numbers 1-16 indicate points where samples were taken from the river.

In the laboratory each sample was centrifuged for two minutes at a rate of 1500 revolutions per minute. A drop of the plankton which had been thrown to the bottom of the centrifuge vials was then placed in a Sedgwick-Rafter counting chamber and a quantitative and qualitative study made. As a rule, three

TABLE I  
ZOOPLANKTON ORGANISMS FOUND IN THE HOCKING RIVER

PROTOZOA	*Polyarthra
Sarcodina	Pterodina
Arcella	Rattulus
Diffugia	*Rotifer
Mastigophora	Triarthra
Ceratium	NEMATHELMINTHES
Eudorina	Nematoda
*Euglena	ANNELIDA
Gonium	Chaetopoda
*Pandorina	Chaetogaster
Phacus	Dero
Volvox	Naidium
Infusoria	Nais
*Colpidium	Limnodrilus
Paramecium	Stylaria
Stentor	Tubifex
Stylonichia	ARTHROPODA
Euplotes	Crustacea
Urocentrum	Cladocera
Vorticella	Alona
TROCHELMINTHES	Bosmina
Rotifera	Ceriodaphnia
*Anuraea	Chydorus
Asplanchnia	Daphnia
Brachionus	Pleuroxus
Cathypna	Copepoda
Diglena	Canthocampus
Diplois	*Cyclops
Monostyla	Diaptomus
*Noteus	Insecta
Notops	Chironomid larvae
Pedetes	Arachnida
Pedalion	Macrobiotus
Philodina	

\*Genera represented by an average of one organism per liter of water throughout the year.

samples were examined from each centrifuged sample. Identification was limited to genera (Ward and Whipple, 1918).

The H-ion concentration was measured by the LaMotte colorimeter. Samples of water for dissolved oxygen determination were taken during the months of February, March, April, May, June, and October. These samples were obtained with

the Forest water bottle and also by immersing a sampling bottle in the water so that the water filled the bottle from the bottom upward. Determinations were carried out by the Winkler method.

Temperature of the air and water was taken at each station and recorded in degrees Centigrade. A record of the daily river height, precipitation, and temperature at Athens, 65 miles from the source of the river (Station 12) was obtained from the Athens Weather Bureau for the period of time under investigation.

#### THE PLANKTON

Fifty-two genera of zoöplankton organisms representing five phyla were identified during the investigation. The classification of these organisms appears in Table I. Of these, only eight genera were represented by an average of one organism per liter of water throughout the year. An asterisk has been placed before these eight genera in the classification table.

#### THE LONGITUDINAL DISTRIBUTION OF PLANKTON

The quantitative distribution of the plankton at the various stations is shown in Table II. At the bottom of this chart is a total of the number of genera represented by the occurrence of one or more individuals per liter of water at each station during the investigation. The greatest number of genera represented by more than one individual per liter was found at Stations 3, 4, 12, 13, and 14; Stations 5, 11, 15, and 16 rank next; Stations 6, 7, 8, 9, and 10 were represented by still fewer. At Stations 1 and 2 no genus was represented by more than one individual per liter.

Considering the average number of plankters per liter of water, as shown in Table III, it was found that Stations 3, 4, 12, and 13 were most abundantly populated, with an average of more than 80 plankters per liter of water. Stations 5, 8, 14, and 15 ranked next. Stations 6, 7, 9, 10, 11, and 16 were populated by an average of less than 21 individuals per liter. Stations 1 and 2 rank lowest.

Combining the results of these two aspects of quantitative distribution, namely, the number of genera represented by more than one individual per liter and the average number of plankters per liter, it will be seen that Stations 3, 4, 12, and 13 are indisputably the most abundantly populated, while at Stations 1 and 2 plankters were least abundant.

A compilation of the physical and chemical data, excluding the amount of dissolved oxygen and the H-ion concentration,

TABLE II  
COMPOSITION OF THE PLANKTON LONGITUDINALLY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Arcella.....	-	-	-	-	-	-	-	-	-	x	x	xx	xx	xx	x	x
Colpidium.....	-	-	xx	xx	xx	x	xx	xx	xx	xx	xx	xxx	xx	-	x	x
Diffugia.....	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-
Eudorina.....	.	.	.	.	.	.	.	.	.	.	.	.	xx	xx	xx	x
Euglena.....	-	-	xxx	xxx	x	x	xxx	xxx	xxx	xx	xx	x	-	-	.	-
Pandorina.....	-	-	-	.	-	-	-	-	x	x	xx	xxx	xxx	xxx	xxx	-
Paramecium.....	-	-	xxx	xx	xx	-	-	-	-	-	-	-	-	-	-	-
Stentor.....	.	-	-	xx	x	-	-	-	.	.	.	.	-	.	.	.
Euplotes.....	-	-	-	x	-	-	-	-	-	-	-	-	.	.	.	.
Vorticella.....	-	-	-	xx	x	x	-	-	-	-	-	-	-	-	-	-
Anuraea.....	-	-	-	-	.	-	.	-	-	-	-	x	xx	xxx	xx	xx
Brachionus.....	-	-	-	-	x	-	-	-	-	-	-	xx	xx	xx	x	x
Cathypna.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monostyla.....	-	-	.	-	.	-	.	-	-	.	.	-	-	xx	-	-
Noteus.....	-	-	.	.	-	-	.	-	-	-	-	xx	xxx	xx	xx	xxx
Notops.....	-	.	-	-	-	-	-	-	-	-	-	x	xx	x	-	-
Philodina.....	-	-	xx	xx	xx	x	-	-	-	-	-	-	-	-	-	-
Polyarthra.....	-	-	.	.	.	.	.	-	-	-	xx	xxx	xxx	xx	-	.
Pterodina.....	-	-	-	-	-	-	-	.	-	-	-	-	.	-	.	-
Rattulus.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rotifer.....	-	x	xxx	xxx	xxx	xx	xx	xx	x	x	xx	xx	xx	x	x	xx
Triarthra.....	-	-	-	.	-	.	-	-	.	-	-	x	-	-	.	-
Nematoda.....	-	x	xx	xx	x	x	x	x	-	-	x	xx	xx	x	x	-
Annelida.....	-	-	-	-	-	-	-	.	.	.	-	-	-	.	-	-
Cladocera.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copepoda.....	-	-	-	-	-	-	-	x	x	x	x	xx	xx	xx	xx	xx
Insecta.....	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
Genera with more than one indi- vidual per liter.....	0	0	6	8	4	2	2	3	2	2	5	9	12	10	5	4

xxx More than five individuals per liter.

xx One to five individuals per liter.

x Five-tenths of one to one individual per liter.

- Less than five-tenths of one individual per liter.

. Absent.

as it appeared at each station, is included in Table III. An analysis of these factors follows.

The Hocking River, although not as rapid a stream as a number of others in the state, moves along without marked retardation over most of its course. Only at Station 13, where

its flow is retarded by a dam, and at Station 16, where it empties into the Ohio River, does the river become sluggish. At station 13 there were, on an average, eighty plankters per liter of water. However, with this exception, there is no pronounced increase in the average number of plankters in the lower portion of the river where the flow is somewhat retarded as compared with its rapid flow in the upper portion (Table III).

The temperature in the lower portion of the stream averaged slightly higher than the temperature at the stations near the

TABLE III  
PHYSICAL AND CHEMICAL FACTORS AS THEY OCCUR AT EACH STATION

Stations	Rate of Flow Determined by Topography	Yearly Averages of Temperature of Water	Age of Stream	Average Plankters Per Liter
1	Rapid	12.0° C.	Young	2.0
2	Rapid	14.3° C.	Young	2.5
3	Rapid	14.8° C.	Old	345.0
4	Rapid	14.5° C.	Old	194.0
5	Rapid	13.5° C.	Mature	27.0
6	Rapid	13.8° C.	Adolescent	10.0
7	Rapid	13.7° C.	Mature	21.0
8	Rapid	14.2° C.	Old	40.0
9	Rapid	14.8° C.	Mature	20.0
10	Rapid	14.7° C.	Adolescent	8.5
11	Rapid	14.0° C.	Adolescent	15.0
12	Retarded	14.9° C.	Old	94.0
13	Sluggish*	15.4° C.	Old	80.0
14	Retarded	15.0° C.	Old	40.0
15	Retarded	15.2° C.	Mature	28.0
16	Sluggish†	16.1° C.	Mature	17.0

\*Dam.

†Backwater.

source of the stream. It is apparent that the higher temperature and the abundance of plankters per liter in the lower portion of the river correlate closely (Table III).

"Old" age of the stream, in the sense used in Table III, refers to any region of the river where it becomes productive, as indicated by the great increase in the number of plankters. Regions where the stream was not productive were designated as "young," "adolescent," or "mature" regions, depending on the number of plankters present. It has been pointed out that the plankton was abundant at various stations in the lower half of the river; therefore, those regions were designated as being old. A somewhat retarded rate of flow and higher temperature

can be correlated with the productivity at these stations. Furthermore, Stations 3 and 4 were highly productive; therefore, they too might be considered as old regions of the stream. Retarded rate of flow and higher temperature of water cannot be correlated with the productivity at these stations. It will be recalled, however, that at Station 3, just below the city of Lancaster, the river receives a great amount of domestic sewage. Again, at Station 8, below the town of Logan, and at Station 12, just below the city of Athens, a large amount of domestic sewage is emptied into the river. Here, too, are productive regions of the river. Therefore, it seems apparent that a region may be rendered productive by addition of domestic sewage. In fact, such addition seems to counteract detrimental effects of rapid rate of flow and lower temperature as found at Stations 3 and 4. Sewage probably stimulates productivity directly by acting as food, and indirectly by rendering conditions favorable for increases in bacteria which in turn act directly as food.

The productivity of the river at Station 10, below the town of Nelsonville, is an exception to the statement that organic wastes act as stimulators of productivity. However, the influence of mine and brick plant wastes can, in all probability, account for this deviation.

The dissolved oxygen content of the water was lowest at those stations where the greatest number of organisms occurred and where sewage disposal was greatest. This might be expected, for the greater the number of organisms present, and the greater the amount of sewage, the more oxygen consumed.

The H-ion concentration varied so slightly throughout the course of the stream that effects were not apparent.

The qualitative distribution of the plankton genera appearing most abundantly is indicated by fig. 2. The figure shows that certain forms were more characteristic of some portions of the river than of others. Forms such as *Paramecium*, *Stentor*, *Euplotes*, *Vorticella*, and *Philodina* seem to be characteristic of the upper portions of the stream, especially at Stations 3, 4 and 5. Forms such as *Arcella*, *Eudorina*, *Pandorina*, *Anuraea*, *Brachionus*, *Noteus*, *Polyarthra*, *Copepoda*, and insect larvae appeared more often in the lower portions of the stream, Stations 11 to 16.

Since Stations 3 and 4 are rendered productive, quantitatively speaking, by domestic sewage, it seems probable that the

qualitative nature of the distribution at those points is also, at least in part, determined by pollution. Forms such as *Stentor* and *Euplotes* were found to be present in this region of the

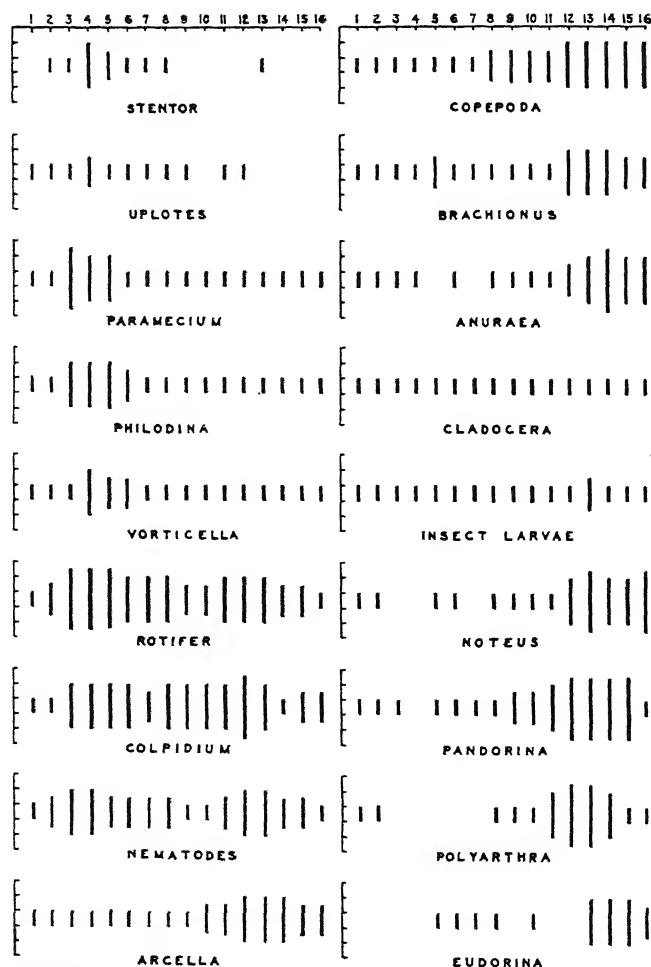


Fig. 2. Qualitative distribution of zooplankton organisms.  
 — less than five tenths of one individual per liter.  
 — five tenths to one individual per liter.  
 — one to five individuals per liter.  
 — more than five individuals per liter.

stream and to disappear entirely in the lower regions. In addition, *Paramecium*, *Philodina*, and *Rotifer* might be considered as abundant forms in regions of high sewage concentration. On the other hand, forms such as *Polyarthra* and *Eudorina* were

never found in this region where sewage was concentrated. However, they appeared in great numbers at Station 12 where the amount of sewage disposed is great; but it must be kept in mind that the concentration of pollution at that station is greatly altered by an increase in the amount of water. The river is approximately three times as wide and four times as deep at Station 12 as at Station 3.

Following a model by Wiebe (1927), Table IV has been made, the purpose being to indicate, by numbers representing abundance, the qualitative distribution of zoöplankters with reference to degree of pollution. It can be stated that these results correspond favorably with those of Wiebe.

TABLE IV  
MOST ABUNDANT ZOÖPLANKTERS AT EACH GROUP OF STATIONS

Genus	Group I Rank	Group II Rank	Group III Rank	Genus	Group I Rank	Group II Rank	Group III Rank
Arcella.....	3	2	2	Anuraea.....		2	1
Eudorina.....		2	1	Brachionus.....	3	2	2
Euglena.....	1	1	2	Noteus.....		2	2
Pandorina.....		1	1	Notops.....	3	2	2
Colpidium.....	2	2	2	Philodina.....	1	2	2
Paramecium.....	1	2	1	Polyarthra.....		2	1
Stentor.....	4			Rotifer.....	1	2	2
Nematode.....	2	2	2	Cyclops.....	3	2	2

Group I—Extremely polluted stations 3, 4, and 5.

Group II—Moderately polluted stations 8, 10, 12, and 13.

Group III—Comparatively unpolluted stations 6, 7, 9, 11, 14, 15, and 16.

Rank 1—very abundant; Rank 2—present; Rank 3—scarce; and Rank 4—present only in one portion.

Degree of pollution can be considered, then, as a factor partially responsible for both the quantitative and qualitative distribution of plankton along the course of the Hocking. Retarded rate of flow, size of stream as influencing degree of pollution, and higher temperature must also be considered as partially responsible for distribution, especially of such forms as *Pandorina*, *Polyarthra*, the cladoceran *Chydorus*, and insect larvae.

#### DISTRIBUTION BY MONTHS

Figure 3 shows that the plankton was more abundant during the summer and autumn months (June to December), than during the winter and spring months (December to June). The



months during which conditions were apparently most favorable for various plankters were:

PHYLUM	MONTHS
Protozoa.....	June, August, September
Rotifera.....	June, August, September
Annelida.....	June, November
Arthropoda.....	June, September, November

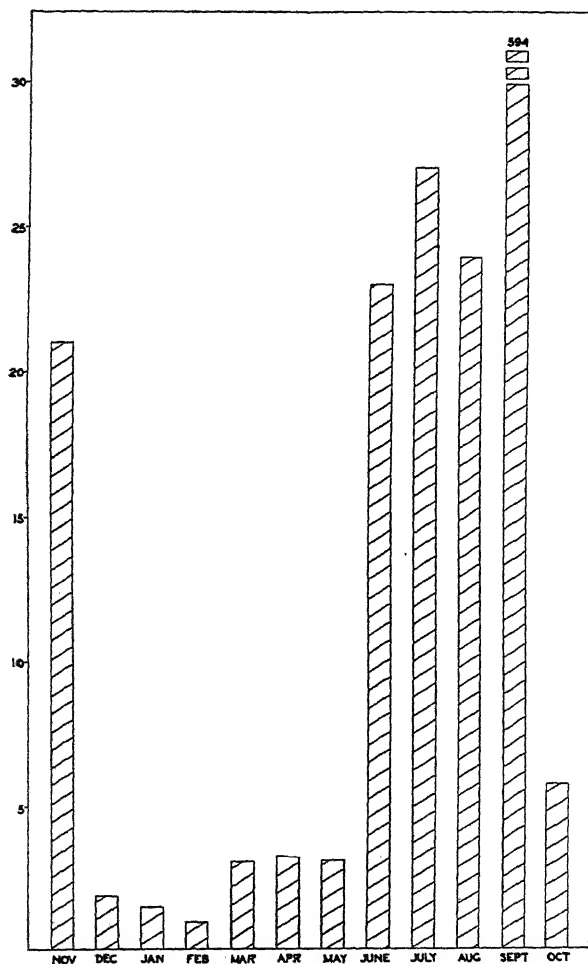


Fig. 3. Monthly distribution of zoöplankton. The number of individuals per liter is indicated on the ordinate.

The monthly distribution of the plankters is shown in Table V. This table and figure 3 illustrate that minimum production occurred at times of low temperatures. Water tem-

peratures were lowest in the months of January and February, averaging 4.0° C. and 4.5° C. respectively, and highest in the month of July, averaging 27° C. Figure 3 shows that the smallest numbers of organisms were present during the months of

TABLE V  
DISTRIBUTION OF PLANKTON BY MONTHS  
(Individuals per Liter)

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
Arcella.....	2.3	0.1		—	0.3	0.1	—	0.4	0.4	0.3	3.9	0.1
Colpidium.....						.4	.1	...	21.8	.2	.1	...
Diffugia.....	—	...	...	...	...	.9	—	...	.9	.2	.2	.6
Eudorina.....	...	...	...	...	...	...	—	...	...	6.6	—	...
Euglena.....	.1	...	...	...	—	...	...	.3	...	.2	340.0	.1
Gonium.....	...	...	...	...	...	...	...	...	...	.8	1.0	...
Pandorina.....	...	...	...	...	—	—	—	...	.4	—	65.6	...
Paramecium.....	.7	.2	—	...	—	—	.1	4.0	.5	.2	1.1	...
Stentor.....	—	...	...	...	...	...	...	1.0	.1	.1	.6	...
Euplotes.....	.2	—	—	...	...	—	—	.6	—	—	...	...
Vorticella.....	.4	.1	—	...	.5	.9	.3	.7	...	...	.6	.1
Anuraea.....	.1	...	...	...	...	...	—	...	...	...	14.5	—
Brachionus.....	1.7	—	...	—	—	—	.2	.5	.7	1.0	2.4	.2
Monostyla.....	...	...	...	...	...	...	...	...	...	...	.9	.2
Noteus.....	.5	...	...	...	...	...	...	...	.4	10.0	5.7	—
Notops.....	.9	—	...	...	...	...	...	...	...	...	2.2	...
Philodina.....	.5	.1	.1	—	.1	.1	.2	4.7	—	.7	.5	.2
Polyarthra.....	...	...	...	...	...	...	...	...	...	—	50.2	...
Pterodina.....	.6	—	—	...	...	...	...	...	...	...	...	...
Rotifer.....	2.9	.5	.3	.1	.3	.1	.7	9.5	.1	2.8	104.0	2.5
Triarthra.....	...	...	...	...	...	...	...	...	—	...	.9	...
Nematoda.....	2.1	.3	.7	.7	1.2	.5	.7	.3	...	.3	.4	.7
Annelida.....	.1	—	...	...	...	...	—	—	—	—	...	...
Cladocera.....	.8	.1	...	...	—	—	...	...	.2	—	—	.1
Copepoda.....	5.6	.3	.1	—	.3	.1	.2	1.3	.5	.5	1.0	.6
Chironomidae....	1.3	.1	—	—	—	—	—	.1	—	.1	—	.1

— present in numbers less than one-tenth per liter.

January and February, and that the numbers present in July were exceeded only by the numbers present in September when the temperature had not decreased sufficiently to affect plankton productivity. Actually the plankton of February is approximately four per cent of that present in July.

On the basis of data obtained from the Athens Weather Bureau, an attempt was made to correlate stability of hydro-

graphic conditions with abundance of organisms at Station 12, situated at Athens. The results showed that the periods of greatest productivity, both quantitatively and qualitatively, occurred during those months, June, July, August, and September, when hydrographic conditions were most stable. The abundance of organisms in November is an exception to this statement but may be explained by the fact that, during that month, sampling was done the day following the first heavy precipitation for approximately a month. Such a precipitation, according to Kofoid (1903), flushes the back waters and tributaries of their plankton, thereby increasing the numbers in the main stream.

#### DISTRIBUTION BY SEASONS

All plankton occurred more abundantly during the autumn than during any other season. It was interesting to note that the nematodes were least abundant during the summer season. The approximate ratio between the total number of organisms per liter of water during the fall season and the other seasons is as follows:

SEASONS	RATIO	PERCENT
Fall to Winter.....	208 to 1.5.....	$\frac{3}{4}\%$
Fall to Spring.....	208 to 3.0.....	1%
Fall to Summer.....	208 to 25.0.....	12%

Evidence has already been given concerning the effect of low temperatures on monthly plankton distribution. Therefore, the small number of forms present in the stream during the winter season can be ascribed to the effect of temperature. The comparatively small increase in the number of forms during the spring is probably due to the detrimental effect of floods which occurred Feb. 16 and 27, March 22, and April 8.

#### ECOLOGICAL SUCCESSION

An interesting succession of genera occurred at Stations 3, 4, 5, and 6. These stations demonstrate the progressive change of the nature of the stream from an extremely polluted condition to an unpolluted condition. At Station 3, the genera *Euglena*, *Paramecium*, and *Rotifer* occurred abundantly during the entire year. *Stentor*, *Vorticella*, and *Philodina* reached their greatest abundance at Station 4. The nature of the water at Station 5 seemed favorable for *Colpidium*, the numbers of which had increased gradually since Station 3. *Pterodina* and *Chaetogaster* also occurred abundantly at this station. At Station 6 *Volvox*

appeared. This is one of the three stations at which it did occur in the entire stream. *Monostyla*, *Noteus*, *Bosmina*, *Chydorus*, and *Diaptomus* increased markedly at Station 6 in contrast with the reduction they suffered below Station 2. *Eudorina* appeared frequently for the first time at Station 6. *Euglena*, *Paramecium*, *Stentor*, *Euplotes*, *Vorticella*, *Philodina*, and *Rotifer* had decreased considerably in numbers here. It is evident that a change in the polluted nature of the river is accompanied by a change in the occurrence of plankters. Forms which occurred abundantly in the comparatively polluted region of the river gradually declined in numbers, while forms which were present before the river became polluted reappeared after the river had become relatively unpolluted.

#### DISCUSSION

Domestic pollution as a factor determining the qualitative distribution of plankton was included in this paper with a great degree of caution. The results of investigations are not in agreement as to the role, whether active or passive, played by pollution in lotic environments. Roach (1931) in his investigation of the plankton of the Hocking River, discards domestic pollution as an active determining factor in the distribution of plankton. However, Forbes and Richardson (1919), Wiebe (1927), and the report on pollution in the survey of the Genesee River System of New York (1927), support the active role of pollution. In the present investigation the succession of plankton organisms from Stations 3 to 6 accompanying the very profound change from septic tank conditions to clear water, and the occurrence of certain genera in the profoundly polluted regions of the stream, but not elsewhere, indicates that pollution is an active factor in determining the quality of plankton. In terms of quantity, the fact that at Stations 3 and 4 the sewage renders the Hocking productively old before it can become old according to Shelford and Eddy's (1929) statement that water in the Sangamon River was not productive till twenty days old, seems to necessitate consideration of pollution as an active factor in production in the Hocking. This view is supported by Lackey (1938) who, upon investigating factors affecting the distribution of Protozoa, found pollution to be an active factor in quantitative and qualitative distribution.

In general, the results of this investigation are in close agreement with those of other investigators of lotic environments. Kofoid (1903), Allen (1920), and Galtsoff (1924) have

pointed out that a retarded rate of flow is effective in rendering a portion of a stream productive. In the Hocking River the productivity of Station 13, a more slowly moving portion of the river, has been considered due, at least in part, to the retarded rate of flow. However, the investigator, like many others, fails to correlate the decrease of organisms at the last two stations.

The negative correlation between dissolved oxygen and plankton abundance might be expected since at no time did the dissolved oxygen content become less than 3.0 cc. per liter. Welch (1935) states that many animals do not show evidence of response to declining oxygen until it has been reduced to 0.2 or 0.3 cc. per liter, and Kofoed (1908) noted that there was no correlation between seasonal chemical and plankton flux. Both of these statements substantiate, more or less, the above dissolved oxygen and plankton relationship.

Kofoed (1903), Roach (1931), and Reinhard (1931) have described the detrimental effects of floods, the beneficial effects of hydrographic stability, and the effect of tributary plankters on plankton production. Hydrographic stability and flood effects have been noted in the present investigation as vital factors in seasonal and monthly distribution of plankton. The abundance of plankton in the main stream during November has been attributed to the washing in of tributary plankters following heavy precipitation.

The correlation between high temperature and increased plankton production need not be discussed. The fact that nematodes were more abundant during the fall, winter and spring months than during the summer months challenges investigation; resistance by nematodes to extremes in environment has been pointed out in numerous cases (Hoepli, 1926).

#### SUMMARY

1. In a limnological survey of the Hocking River fifty-two genera of zoöplankton were found. The plankton consisted of sixteen genera of Protozoa, seventeen genera of Annelida, and eleven genera of Arthropoda.

2. A combination of retarded rate of flow, higher temperature, and senescence of the water at a given point along the river tend to increase plankton productivity. Domestic pollution probably hastens senescence and increases abundance. Inorganic wastes tend to decrease abundance of organisms.

3. Stability of hydrographic conditions and high temperature, except in the case of nematodes, are important factors in determining the monthly and seasonal distribution.

4. There is some evidence that degree of pollution determines the quality as well as the quantity of plankton along the Hocking River.

#### BIBLIOGRAPHY

- Allen, W. E. 1920. A Quantitative and Statistical Study of the Plankton of the San Joaquin River and Its Tributaries in and near Stockton, California, in 1913. Univ. Calif. Pub., Zool., 22: 1-292.
- Biological Survey of the Genesee River System. Suppl. to the 16th Ann. Rept., State of N. Y. Conser. Comm., 1927, 100 pp.
- Biological Survey of the Oswego River System. Suppl. to the 17th Ann. Rept., State of N. Y. Conser. Comm., 1928, 248 pp.
- Biological Survey of the Erie-Niagara System. Suppl. to 18th Ann. Rept., State of N. Y. Conser. Comm., 1929, 244 pp.
- Eddy, S. 1932. The Plankton of the Sangamon River in the Summer of 1929. State of Ill. Div. Nat. Hist. Surv., 19: 469-486.
- Forbes, S. A., and R. E. Richardson. 1913. Studies on the Biology of the Upper Illinois River. Bull. of Ill. State Lab. of Nat. Hist., Vol. IX.
1919. Some Recent Changes in Illinois River Biology. Bull. of Ill. State Lab. of Nat. Hist., Vol. XIII.
- Galtsoff, P. S. 1924. Limnological Observations in the Upper Mississippi, 1921. Bull. U. S. Bur. Fish., 39: 347-438.
- Hoepli, R. J. C. 1926. Studies of Free-Living Nematodes from the Thermal Waters of Yellowstone Park. Trans. Am. Micr. Soc., 45: 234-255.
- Kofoid, C. A. 1903. The Plankton of the Illinois River, 1894-1899, with Introductory Notes upon the Hydrography of the Illinois River and Its Basin. Part I. Quantitative Investigations and General Results. Bull. Ill. State Lab. Nat. Hist., 6: 95-629.
1908. The Plankton of the Illinois River, 1894-1899, with Introductory Notes upon the Hydrography of the Illinois River and Its Basin. Part II. Constituent Organisms and Their Seasonal Distribution. Bull. Ill. State Lab. Nat. Hist., 8: 1-354.
- Lackey, J. B. 1938. A Study of Some Ecological Factors Affecting the Distribution of Plankton. Ecol. Monogr., 8: 502-527.
- Reinhard, E. G. 1931. The Plankton Ecology of the Upper Mississippi, Minneapolis to Winona. Ecol. Monogr., 1: 395-464.
- Roach, L. S. 1931. An Ecological Study of the Plankton of the Hocking River. Original Thesis for Master's Degree at Ohio University.
1932. An Ecological Study of the Plankton of the Hocking River. Bull. Ohio Biol. Surv., 5: 253-279.
- Shelford, V. E., and S. Eddy. 1929. Methods for the Study of Stream Communities. Ecology, 10: 382-391.
- Ward, H. B., and G. C. Whipple. 1918. Fresh Water Biology. John Wiley & Son, Inc., New York, N. Y.
- Welch, P. S. 1935. Limnology. McGraw-Hill Book Co., Inc., New York, N. Y.
- Wiebe, A. H. 1927. Biological Survey of the Upper Mississippi River with Special Reference to Pollution. Bull. U. S. Bur. Fish., 43: 137-167.

### Survival

The author is a geologist who graduated from Harvard with an A.B., *magnum cum laude*, and later took a Ph.D. at Chicago University with the same label of excellence. He is a top flight writer who has furnished articles for such reviews of distinction as *The Yale Review*, *The American Mercury*, *The Forum*, *The American Scholar* and *Harper's Magazine*.

The volume is an excellent popular review from an evolutionary point of view of life in terms of the latest biological thought. Apparently the work is not intended for the scientific student, as it is neither indexed nor does it have a bibliography or a detailed table of contents. To the scientist reader it is even annoying at times because the author frequently uses brilliant suggestive or explanatory ideas which apparently are not always original, but which cannot be traced back to an earlier writer for a fuller explanation.

The popular form of the exposition is such through a rich and brilliant use of figures of speech and a sufficient inweaving of the emotional to keep the reader awake and even on his toes for fear he will miss some of the more thrilling incidents in this panorama of life. From the view of cold logic the author has overwritten his subject.

The contents run as follows:

"The Question and the Quest." After pointing out the conflict in biological philosophy between mechanism and vitalism the author suggests, "The student of earth history sees in retrospect what could never have been foretold. Life was a new experiment under the sun. A bit of jelly quivering to the surge of the sea might scarcely have been suspected of power to alter the earth. . . . If there is any meaning . . . in the restless drive of life, a billion years of living should contain it. To search those years for that meaning will be the object of this book."

Chapter I. "In the Beginning:" a discussion of Pre-Cambrian conditions. Chapter II. "The Other Side of Progress:" sedentary life. III. "The Mechanics of Success:" evolution and locomotion. IV. "The House Divided:" biological conflicts, plant life, herbivores, carnivores, food chains, over-population. "The house of life divided against itself stands only because it is divided." V. "Life Without Struggle:" the degeneracy of parasitism, with an interesting review of human social parasites. VI. "The Way of Love:" bisexual reproduction, maternal care, family life, co-operation. VII. "The Broader Brotherhoods of Flesh:" life at unicellular level, at coelenterate and colonial level at the level of herd life and at social levels. VIII. "The Tragic Rhythm:" death in too high specialization, other evolutionary trends, life only possible hand in hand with death and extinction. IX. "The Business of Growing Up:" various evolutionary "improvements" and their values. X. "Is Man an Absurdity? When Nature evolved modern man, she improved only the brain, the larynx and the hands and allowed all other essential gadgets to degenerate. . . . Man is an appalling hodge-podge of second-hand odds and ends," but "the gravest dangers for man as a species lie less in the crumbling beast than in the bungling god." XI. "The Embarrassment of Being Different. . . . No other creature has faced sterner problems with fewer guides to workable solutions, but solutions may come through man's unique feature of discontent with discontent. . . . Self-directed evolution so far as he knows, is an adventure without precedent in a billion years."

The exposition is full of minor errors of fact, many of which could have been caught by competent readers. We quote, p. 152, "Drone bees are so specialized as gigolos that they are incapable of any other pursuit. They are unable to gather pollen (*should be* nectar) because their tongues are too short. They are unable to work on the hive because they have no wax glands (*Should be* because of their nervous mechanism). They are unable to fight because they have no stings (*again* because of the nervous control of behavior). They would rather starve than collect food for themselves" (*anthropomorphic expression*). This careless writing disregards all previous careful observations and precise experimentation by scientists in general.

The volume is so full of highly suggestive ideas (though too frequently based on highly selected evidence) that we recommend it in spite of its numerous minor slips. It is interesting and actually absorbing page after page.—C. H. Kennedy.

**Patterns of Survival**, by John Hogden Bradley. 223 pp. New York, The Macmillan Co., 1938. \$2.25.

# THE EFFECTS OF MAN-MADE MODIFICATIONS ON THE FISH FAUNA IN LOST AND GORDON CREEKS, OHIO, BETWEEN 1887-1938

MILTON B. TRAUTMAN  
Franz Theodore Stone Laboratory,  
Ohio State University,  
Put-in-Bay, Ohio

If the fundamental principals regulating the present numerical abundance of a species are to be understood, it is necessary to obtain some understanding of the numerical fluctuations of that species over a comparatively long period of time and to learn the reasons for such fluctuations. Research to determine these facts is not very difficult with such conspicuous animals as the black bear, white-tailed deer, passenger pigeon, or bob-white. It is more difficult with fishes, principally because of the inability of early observers to identify correctly these usually inconspicuous animals. As a consequence, there are few dependable observations in Ohio on fishes during early historic time. One of the finest series of observations available is from the Lost and Gordon creek systems of the Maumee drainage, in Defiance and Paulding counties of western Ohio.

This portion of the Maumee Valley was first invaded by small numbers of white men early in the eighteenth century. Fort Defiance, Defiance County, was built in 1794, and this site, where the city of Defiance now stands, has since been continuously occupied by the white man. Before 1794 Indians had a settlement there, which extended along the Maumee River for a considerable distance (Howe, 1902: 541-542). Adjacent to the village there was said to have been "highly cultivated" land "with one thousand acres of corn besides immense apple and peach orchards."

Despite early occupancy about the present site of the city of Defiance, the counties of Defiance and Paulding were not heavily settled, nor was much land cultivated, until after 1850. These counties lay principally in the Black Swamp, and the topography of this swamp prohibited ready drainage. Extensive ditching was not begun until after 1850. Even as late as 1874 (Winchell, 1874a: 438) almost two-thirds of Defiance County still contained heavy forests. In Paulding County "about eighty-nine per cent of the acreage was classified as



uncultivated" and deer, black bears and wolves were still sufficiently numerous to attract hunting parties from as far distant as southern Ohio (Winchell, 1874b: 335-336).

The first published ichthyological explorations of Defiance County began in 1887, during the early period of swamp drainage and forest removal. In July of that year Meek<sup>1</sup> made his investigations of the Lost and Gordon creek systems. In 1889 Meek (1889: 435-440) published a list of the fishes captured, indicated their abundance, and gave a short, accurate description of the streams and adjacent country.

Meek stated that he seined in the following localities, spending less than a day in each: Gordon Creek about one mile above its mouth; the same creek about ten or twelve miles upstream near Cicero;<sup>2</sup> and Lost Creek about two and a half miles southwest of Farmer. He described Gordon Creek as small, containing little or no flowing water in summer, and with the pools becoming nearly dry at that season. When he seined the stream near its mouth in 1887 it had ceased to flow and collecting was done in a few *deep holes*. The creek near Cicero was little more than a small brook with a muddy bottom and occasional stretches of sand. Meek stated that Lost Creek was larger than Gordon, and that it had a more sandy bottom; that it was fed by springs in the headwaters, and was seldom, if ever without running water. A few miles below Farmer, Lost Creek lost itself in a large marshy tract of land that was covered with a dense growth of underbrush.<sup>3</sup>

Meek mentioned that formerly the greater portion of Defiance County was heavily timbered, and that within the past thirty years much land had been cleared. He also stated that although large woodland remnants remained, most of them had been depleted of their best timber, and the remaining trees had been more or less injured by fire. Meek's description of the country agrees with those of other competent writers of that period and region.

A rather detailed survey of the Maumee river system was made in the summer of 1893 by Philip H. Kirsch. His report

<sup>1</sup>Seth E. Meek, one of America's outstanding ichthyologists, was born in 1859 at Hicksville, Defiance County, Ohio. His investigations were conducted in Farmer, Mark and Hicksville townships, Defiance County.

<sup>2</sup>This former village is not usually shown on recent maps. It was located in northeast Hicksville Township, Defiance County. See U. S. Geol. Surv. map, Bryan Quadrangle, Ohio; 1914.

<sup>3</sup>Seemingly that portion of Mark Township that is enclosed in a dotted line on Winchell's map (1874a: opp. p. 422).

(1895: 315-337) gives us an accurate conception of the numerical status of many fish species throughout the Maumee system, which materially assists in our understanding of the population fluctuations and physical modifications that have occurred in the creeks under discussion. Kirch included Meek's data in his report but did not personally investigate Lost or Gordon creeks.

Dr. Raymond C. Osburn and Mr. Edward L. Wickliff began in 1920 a state-wide survey of fishes for the Ohio Division of Conservation, which included collecting in the Maumee drainage. I began to assist in this survey in 1925 and since have made many collections in the Maumee system. I first collected in Lost and Gordon creeks in 1930, and was then assisted by Mr. Robert B. Foster.

On May 22 and 30, 1938, Mr. George A. Moore<sup>4</sup> and I began the investigations of Lost and Gordon creeks which have made this comparative study possible. We collected fishes in every locality seined by Meek, and in eight others as well. The major physiographic features of both stream systems were observed, as were the major floral types. It was apparent that vast modifications had occurred in the streams and watersheds since 1887. All except small sections of the streams had been dredged or straightened. Dredging to a depth of fifteen and twenty feet had completely drained that section of Lost Creek where the stream had formerly "lost itself in a large marshy tract of land (Meek, 1889: 435)." In several localities dredging had penetrated into a hard pan of grayish-blue clay. The most recently dredged sections contained no pools or well-defined riffles, the depth of water was uniformly shallow and the bottom cover was almost or entirely absent. Wherever hard-pan occurred it was swept clean except for occasional, small accumulations of sand and small-sized gravel. Rooted aquatic vegetation was absent. Wherever the dredging had occurred five or more years previously, bank cutting, and occasional lodged stumps and timber had begun to cause the formation of pools and sand bars. The straightening and dredging of the former, meandering creeks caused the formation of ox-bows. Some of the ox-bows were only a few yards, others were almost a mile in length. Many were connected with a dredged ditch except in periods of low water. Some contained a series of interrupted pools. None had flowing water. All possessed a profusion of

---

<sup>4</sup>I wish to acknowledge indebtedness to Mr. Moore, of the Oklahoma Agricultural and Mechanical College, for his assistance in the collection of field data.

algae, and some contained much submerged and emergent rooted aquatic vegetation.

The undredged portions of both stream systems were in the headwaters. These sections were characterized by well-defined pools of as great as seven feet in depth, in which was usually an abundance of timber, boulders, gravel, rooted aquatic vegetation and other cover for fishes. The riffles were likewise well-defined and contained much cover in the form of boulders, gravel and vegetation. It is assumed that conditions in these undredged sections, and particularly where they flowed through woodlands, were comparable to conditions in 1887.

Because of topographical features the headwaters of Lost Creek, and to a lesser extent of Gordon Creek, are very different from the lower courses. Many of the tributaries of Lost Creek and a few of those of Gordon Creek began at about 825 feet above sea level, and in the first one or two miles of their course drop to 750 feet.<sup>5</sup> At about the 750 foot level the streams enter the former Black Swamp, and in the remaining 3 to 15 miles descend only about 50 feet. Most of the headwater tributaries flow at right angles through a series of ridges, of which two are outstanding. These lie parallel to each other, and cross Hicksville and Farmer townships, Defiance County, in a northeast-southwest direction. The upper one has been called the lower margin of the St. Mary's Ridge, and the other the Van Wert Ridge (Winchell, 1874a: 430, and map opp. p. 422). Springs and artesian wells are numerous on these uplands and particularly about the headwaters of Lost Creek. The soil on the uplands is of moderate fertility, is readily eroded, and often contains much gravel, sand and many boulders. Occasional sand blow-outs occur. The flora of the most sandy portions is of an oak-opening type. The former forests have been reduced to remnant woodlands and woodlots, and are usually grazed. The meadows are often heavily grazed, and all except an occasional fence row or stream bank is under some form of cultivation.

The lower courses of the streams, which formerly meandered across the Black Swamp, now traverse a level, well-drained plain whose usually dark, sandy-loam soil is in general very fertile. The remnant woodlands, of swamp-forest type, are few and are generally grazed. The remaining portion of the plain is under intensive cultivation except for an occasional fence row

---

<sup>5</sup>See U. S. Geol. Surv. map. Bryan Quadrangle, Ohio; 1914.

or stream bank. The loamy soil erodes rapidly along the stream banks and wherever there is sufficient slope.

Meek's report indicates that he found collecting conditions favorable in 1887, and that a fairly representative sample of the fish fauna was obtained. Collecting in 1938 was conducted under extremely favorable conditions, and all habitat types were given equal attention. Table I compares the results of these two investigations.<sup>6</sup>

It will be observed that Meek recorded 22 species from Lost Creek, 21 species from Gordon Creek, and had a total of 26 species from both. I collected 30 species in Lost Creek, 26 in Gordon Creek, and had a total of 33 species for both. Together Meek and I obtained a total of 41 species for the two systems.

Meek recorded 7 species which I failed to obtain. Of these *Dorosoma cepedianum*, *Moxostoma duquesnii*, *Notropis volucellus*, *Esox vermiculatus*, and *Lepomis megalotis* probably still occur in the two systems and further collecting might reveal them. Since all five are essentially pool or bayou inhabitants I assume that recent dredging has decreased the amount of their habitat and greatly disturbed much of that remaining. Consequently their numbers have decreased. The fish recorded by Meek as *Chrosomus erythrogaster*, if that species, occurred as a relict in the clear, spring streams of the uplands. If the species was the bog-inhabiting *Chrosomus eos*, then it inhabited the Black Swamp proper. The former species seems the most logical.<sup>7</sup> I was unable to find the lowland-inhabiting *Aphredoderus sayanus*, a species recorded only in one other locality in Ohio. It has probably become extirpated with the draining of the Black Swamp.

I collected 15 species which Meek failed to obtain. Of these *Carpiodes cyprinus*, *Minytrema melanops*, *Notemigonus crysoleucas*, *Schilbeodes gyrinus*, *Fundulus notatus*, and *Cottus bairdii* were assumed to have been present in 1887. *Hypentelium nigricans* and *Notropis deliciosus* may have been present but probably have become more numerous recently with the

<sup>6</sup>Since Meek employed comparative terms I have done likewise. In most instances these terms are adequate for the present purpose.

<sup>7</sup>I have corresponded with Dr. Alexander Wetmore of the National Museum, Mr. Alfred C. Weed of the Field Museum, and Mr. H. Walton Clark of the California Academy of Science concerning the existence of specimens collected by Meek in Lost and Gordon Creeks. None are present in any of these institutions. In a letter of January 24, 1939, Dr. Wetmore informed me that, although Meek obtained U. S. Nat. Mus. catalogue numbers for his specimens, the fish were probably never forwarded to that Museum. Because of failure to find Meek's material I have been unable to recheck his identifications.

increase in amount of sandy riffles and pools. *Moxostoma erythrurum* and *Moxostoma rubriques* were probably present, and if so were recorded, in part at least, as *Moxostoma duquesnii*. *Cyprinus carpio* was probably not present in Lost and Gordon Creeks in 1887, since the first introductions in the Maumee system had taken place only a few years before (Cole, 1905: 547). *Phenacobius mirabilis*, a species readily identified, was not recorded in the Maumee drainage until 1920 (Osburn, Wickliff and Trautman, 1930: 173). Since then this inhabitant of roily, prairie-like streams has numerically increased so rapidly that it is now one of the dominant species throughout the Maumee drainage. I assume that the bullheads recorded by Meek as *Ameiurus nebulosus* were *Ameiurus natalis*. *A. nebulosus* is seldom found in small streams in Ohio and is numerous only in ponds, lakes or large rivers. *A. natalis* is abundant in small streams similar to the undredged portions of Lost and Gordon Creeks, and in these streams I found them in good numbers. *Etheostoma blennioides* was probably present but may have invaded the two systems since the draining of the Black Swamp. *Pomoxis annularis* should have been present in 1887. Its numbers may have recently increased because the species thrives in roily water, and has been stocked repeatedly in the two systems in recent years.

The most interesting facts are obtained from a comparison of the numerical status of species collected by both Meek and me, and from a study of conditions in which these fish were found. Table I and additional data indicates:

The collections from *undredged* sections show that, with few exceptions, there has been little change in numerical abundance of the various fish species in these sections between 1887 and 1938.

The collections from *dredged* sections indicate that, with few exceptions, there has been a drastic change in numerical abundance of the various fish species in these sections between 1887 and 1938.

The food fishes, including the sucker *Catostomus commersonii*, suckers of the genus *Moxostoma*, bullheads of the genus *Ameiurus*, and all sunfish species except possibly *Pomoxis annularis*, were notably less numerous in 1938 than in 1887. Their numerical decrease was apparently the result of dredging, which has destroyed much of their habitat.

The forage fishes that displayed the greatest decrease in numbers were those requiring clear water, a constant flow, well-defined pools, or aquatic vegetation. Included in this group were such species as *Nocomis biguttatus* and *Rhinichthys atratulus*. These were numerous only in undredged sections.

The forage fishes that displayed the greatest numerical increase are all tolerant of dredged conditions with its resultant increase in turbidity of water and accumulation of clean-swept sand, rapid fluctuations in height of flow and speed of current, and lack of rooted aquatic vegetation and other cover. *Ericymba buccata*, the recent invader *Phenacobius mirabilis*, and *Pimephales promelas*, are excellent examples.

Although food fishes have decreased numerically, no obvious change in total numbers of forage fishes is apparent. Seemingly the increase in numbers of those forage species tolerant to dredged conditions tends to balance the numerical decrease of those not tolerant to dredging. Therefore from a cropping standpoint the streams today are essentially bait producers.

Ichthyological investigations of the past and present show that some species, which are rather generally distributed elsewhere in Ohio in similar habitats, are conspicuously absent in Lost and Gordon Creeks. The clear, undredged headwaters seem particularly suited to the big-eyed chub *Hybopsis amblops amblops* (Rafinesque); the rosy shiner *Notropis rubellus* (Agassiz); the rainbow darter *Poecilichthys coeruleus* (Storer); and the fan-tailed darter *Catnotus flabellaris flabellaris* (Rafinesque). Since Kirsch (1895), E. L. Wickliff, myself and others have found these species very rare or absent in the Black Swamp section of the Maumee drainage, may it not be that they have been unable to penetrate the lowland streams and thus reach the upland tributaries with their apparently suitable habitats?

Investigations also indicate that such species as the silver mullet *Moxostoma anisurum* (Rafinesque); the yellow stone catfish *Noturus flavus* Rafinesque; the brindled madtom *Schilbeodes miurus* (Jordan); the mud pickerel *Esox vermiculatus* Le Sueur; and the northern sand darter *Ammocrypta pellucida pellucida* (Baird), were more numerous in the Maumee drainage in 1893 (Kirsch, 1895) than subsequently. It is suggested that possibly their apparent numerical decrease was the result of a reduction in the amount of habitat suitable for them.

The collecting in the Lost and Gordon systems has not produced one small-mouthed bass *Micropterus dolomieu dolo-*

*mieu* Lacépède or a large-mouthed bass *Huro salmoides* (Lacépède), and this despite repeated plantings during recent years. Both species have been in the Maumee River adjacent to Gordon Creek since 1887 (Meek, 1889: 439), and therefore could have readily invaded that stream. Anyone acquainted with the ecological conditions under which the two bass species live in Ohio streams can readily understand why these species are not numerous in Lost and Gordon Creeks. This is particularly true of dredged sections.

In conclusion I wish to point out that in Ohio the absence of game species and the recent decrease of pan and food fishes is not confined to the Lost and Gordon systems. Man-made modifications, such as are now present in these systems, are also present in much of Ohio's waters. One needs only to study the past and present numerical status of Ohio fishes to realize the truth of this statement.

#### LITERATURE CITED

- Cole, Leon. J. 1905. The German carp in the United States. Report of U. S. Bur. of Fish. (1904); 523-641, Pls. 1-3.
- Howe, Henry. 1902. Historical collections of Ohio. C. J. Krehbiel and Co., Cincinnati, 1: 1-922.
- Kirsch, Philip H. 1895. A report upon investigations in the Maumee River basin during the summer of 1893. Bull. U. S. Fish Comm., 14: (1894). 315-337.
- Meek, Seth E. 1889. Notes on a collection of fishes from the Maumee valley, Ohio. Proc. U. S. Nat. Mus., 11: (1888). 435-440.
- Osburn, Raymond C., Edward L. Wickliff and Milton B. Trautman. 1930. A revised list of the fishes of Ohio. Ohio Journ. Sci., 30: (3), 169-176.
- Winchell, N. H. 1874a. The geology of Defiance County. Rept. of Geol. Surv. of Ohio. 2: Pt. 1, 422-438, 1 map.
- 1874b. Report on the geology of Paulding County. Rept. of Geol. Surv. of Ohio. 2: Pt. 1, 335-351, 1 map.

TABLE I. RELATIVE ABUNDANCE OF VARIOUS FISH SPECIES AS RECORDED IN 1887 AND 1938

SPECIES	1887 (Meek)			1938 (Trautman)				REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS	LOST CREEK		GORDON CREEK		
				Dredged	Undredged	Dredged	Undredged	
<i>Dorosoma cepedianum</i> (Le Sueur) Gizzard Shad		Rather abundant near mouth						Probably occurs at present near mouth of Gordon Creek
<i>Carpiodes cyprinus</i> (Le Sueur) Quillback				one adult		A few young in 1880		Young are numerous in some dredged streams of Paulding and Defiance counties
<i>Catostomus commersonnii</i> (Lacepede) Common White Sucker	Abundant	Abundant	Recorded as <i>Catostomus lereus</i> (Mitchill)	Uncommon or common	Very common or abundant	Uncommon or common	Very common or abundant	More numerous in undredged localities; recorded from every undredged locality
<i>Hyphessilichthys nigricans</i> (Le Sueur) Hog Molly			Recorded as <i>Catostomus nigricans</i> Le Sueur	Usually uncommon; sometimes common where there is considerable sand and gravel	Usually common or abundant on sand and gravel riffles			Increase in amount of sand and gravel probably caused increase in fish numbers
<i>Erimyzon oblongus clarkiformis</i> (Girard) Western Creek Sucker	Scarce	Scarce	Recorded as <i>Erimyzon sucetta</i> (Lacepede)	Scarce	More numerous than in dredged portions	Scarce	Scarce	As elsewhere in western Ohio, this prairie-stream species may migrate up these creeks in large numbers in early spring to spawn.
<i>Minytrema melanops</i> (Rafinesque) Spotted Sucker					1 subadult			Usually occurs in numbers in deep pools of fair-sized streams and not in small creeks such as these
<i>Moxostoma valenciennesi</i> (Le Sueur) Black Mullet	Abundant	Abundant	Meek's <i>M. valenciennesi</i> was presumably a composite of this and the two following					If this species of deep clear water occurs at present, it must be very rare



Table I—(Continued)

SPECIES	1887 (Meek)			1938 (Trautman)					REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS	LOST CREEK		GORDON CREEK			
				Dredged	Undredged	Dredged	Undredged		
<i>Moxostoma erythrurum</i> (Rafinesque) Golden Mullet			Presumably the most numerous <i>Moxostoma</i> in 1887				Young numerous in 1930	Since this sucker is chiefly an inhabitant of gravelly riffles and deep pools of clear streams, it may have been more numerous in 1887 than at present	
<i>Moxostoma rubroqueus</i> Hubbs Greater Redhorse			Probably present but confused with <i>M. duquesnei</i>		1 specimen		1 specimen	Like the preceding, this species is numerous in the Maumee River at the mouth of Gordon Creek	
<i>Cyprinus carpio</i> Linnaeus Carp			First introduced into Great Lakes waters of Ohio in 1879 (Cole, 1906; 1947); probably very local in distribution in 1887		1 small young		A few young taken in a deep pool		
<i>Noemipis biguttatus</i> (Kirtland) Horny-headed Chub	Abundant	Abundant	Recorded as <i>Hybopsis kneriensis</i> ; may have included some <i>Noemipis micropogon</i> (Cope)		Abundant			Abundant in undredged portions of Lost Creek where there was some rooted aquatic vegetation	
<i>Rhinichthys atratulus melaenis</i> Agassiz Western Black-nosed Dace	Not abundant		Recorded as <i>Rhinichthys atronatus</i>		Abundant in spring-fed headwaters that flow from a large moraine			Apparently a relict which has remained in the spring-fed headwaters	
<i>Semotilus atromaculatus</i> (Mitchill) Northern Creek Chub	Abundant	Abundant		Common	Abundant	Uncommon	Common	Most numerous in small undredged waters having well-defined riffles and pools	

<i>Nothopis volucellus volucellus</i> (Cope) Northern Mimic Shiner	Not very abundant		Recorded as <i>Nothopis volucella</i> . Meek was one of the first ichthyologists to separate this species from <i>Nothopis delicatulus</i> .	Common in sandy portions downstream; not in small headwaters		Uncommon; present only near mouth and over a sandy bottom		Probably still occurs sparingly in the deeper pools. Numerous in Maumee River near mouth of Lost Creek.
<i>Nothopis delicatulus stramineus</i> (Cope) Northern Sand Shiner			Recorded by Meek in Maumee River. From Meek's writings (1889: 436-437) it is apparent that he could correctly identify this species	Very common or abundant		A few		Probably has increased greatly in numbers since 1887 because of increase in amount of sand and suitable habitat
<i>Nothopis spilopterus</i> (Cope) Northern Steel-colored Shiner	Not abundant		Recorded as <i>Nothopis vittipiei</i>	Very common or abundant		A few		Not numerous in headwaters; a species tolerant of rocky water.
<i>Nothopis cornutus</i> (Mitchill) Common Shiner	Very abundant		Recorded as <i>Nothopis megalops</i> (Rafinesque)	Abundant	Abundant	Common	Uncommon	Headwaters apparently contain typical <i>N. cornutus frontalis</i> (Agassiz). Downstream portions contain varying percentages of <i>frontalis</i> and intergrades between <i>frontalis</i> and <i>chrysocephalus</i> (Rafinesque)
<i>Nothopis unbrattilis cyanocephalus</i> (Copeland) Northern Red-finned Shiner	Scarce	Scarce	Recorded as <i>Nothopis lythurus</i> Jordan and Gilbert		Scarce or uncommon		Scarce or uncommon	A pool species not tolerant to recent dredging
<i>Dicymba buccata</i> Cope Silver-jawed Minnow	Much less abundant than in Lost Creek	Very abundant		Abundant, especially over a sandy bottom	Usually absent or scarce; abundant only over sandy bottom	Abundant wherever sand is exposed	Usually absent or scarce; present in numbers only over sandy bottom	Dredging with resultant increase of sand apparently resulted in increased numbers of fish
<i>Thynnobius mirabilis</i> (Girard) Sucker-mouthed Minnow			Not recorded by Kirsch (1895)	Uncommon, common or abundant	2 specimens	Rare or uncommon		Apparently a recent invader and one tolerant to turbid water

Table I—(Continued)

1938 (Trautman)										
SPECIES	1887 (Meek)			LOST CREEK				GORDON CREEK		REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS	LOST CREEK		Dredged	Undredged			
				Dredged	Undredged					
<i>Notemigonus crysoleucas</i> <i>auratus</i> Rafinesque Golden Shiner			Recorded as <i>Notemigonus</i> <i>chrysolaemus</i>		Rare, only in weedy pools			Rare, only in ox-bows or weedy pools		
<i>Chrosomus erythrogaster</i> Rafinesque Southern Red-bellied Dace	Scarce		May have been <i>C. eos</i> instead of <i>C.</i> <i>erythrogaster</i> . See p. 279 and foot- note No. 7							A relict in this section of Ohio; may now be ex- tirpated
<i>Hyborynchus notatus</i> (Rafinesque) Blunt-nosed Minnow	More abundant than <i>Pimephales</i> <i>p. promelas</i>	More abundant than <i>Pimephales</i> <i>p. promelas</i>	Recorded as <i>Pimephales notatus</i>	Generally distributed, usually uncommon, only abundant in one locality	Generally distributed, usually common	Generally distributed, usually uncommon	Generally distributed, usually common			Averaging less numerous than <i>Pimephales p. pro-</i> <i>melas</i> and markedly so in dredged portions
<i>Pimephales promelas</i> <i>promelas</i> Rafinesque Northern Fat-headed Minnow	Not abundant	Not abundant	Its scarcity as indicated by Kirsch (1895: 328) suggests that this essentially prairie- stream fish was less common in the Ohio section of the Maumee drainage before 1900 than after 1930 (Trautman: re- cords unpublished)	Common or abundant in all sections except those most devoid of cover	Common or abundant	Common or abundant	Common or abundant			This inhabitant of prairie- like and rocky streams has probably increased greatly throughout northwestern Ohio in recent years
<i>Camptostoma anomalum</i> <i>pullum</i> (Agassiz) Mississippi Tallow- mouthed Minnow		Not very abundant	Recorded as <i>Camptostoma</i> <i>anomatum</i> (Rafinesque)	A few	Uncommon, common or abundant; found at all stations			1 specimen		

<i>Ameiurus melas melas</i> (Rafinesque) Northern Black Bullhead	Abundant	Abundant	Recorded as <i>Ameiurus melas</i>		Uncommon, common or abundant	1 specimen	Uncommon or common	Habitat destroyed by dredging
<i>Ameiurus nebulosus nebulosus</i> (Le Sueur) Northern Brown Bullhead	Very abundant	Very abundant	Recorded as <i>Ameiurus nebulosus</i> ; almost unquestionably misidentified; must have been <i>Ameiurus natalis</i> since <i>nebulosus</i> is a deep-water inhabitant					
<i>Ameiurus natalis natalis</i> (Le Sueur) Northern Yellow Bullhead					Usually common or abundant in pools and especially those contain- ing aquatic vegetation	2 specimens, 1 found hiding under old shoe, other under brick	Usually common in pools, abundant in ox-bows	Habitat destroyed by dredging
<i>Schilbeodes grynus grynus</i> (Mitchill) Tadpole Madtom					1 in weedy pool		2 in weedy ox-bow	
<i>Umbra limi</i> (Kirtland) Western Mudminnow	Rather common in small bayous	Rather common in small bayous			Still fairly common in undisturbed weedy head- water pools			Habitat destroyed by dredging
<i>Esox vermiculatus</i> Le Sueur Mud Pickerel	Not very abundant	Not very abundant	Recorded as <i>Lucius</i> <i>vermiculatus</i>					This inhabitant of weedy bayous may still be present in small numbers in un- dredged portions
<i>Fundulus notatus notatus</i> (Rafinesque) Black-striped Topminnow						2 specimens in 1 collection	Common in undredged ox-bow	
<i>Aphredolerus sayanus</i> (Gilliams) Pirate-Perch		One small specimen taken	Supposed to have been given to U.S. National Museum; catalogued as No. 14979; see footnote No. 1					This relict species has probably been extirpated because of destruction of its habitat
<i>Hadropterus maculatus</i> (Günther) Black-sided Darter	Not abundant	Not abundant	Recorded as <i>Etheostoma eximium</i> (Cope and Jordan)		A few		A few	Inhabitant of the larger- undredged pools that con- tain a moderate flow of water

Table 1—(Continued)

1887 (Meek)			1938 (Trautman)				REMARKS	
SPECIES	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS	LOST CREEK		GORDON CREEK		
				Dredged	Undredged	Dredged		Undredged
<i>Bolbosoma nigrum nigrum</i> (Rafinesque) Western Johnny Darter	Abundant	Abundant	Recorded as <i>Etheostoma nigrum</i> Rafinesque	Uncommon generally; rare in recently dredged portions	Common or abundant in gravelly riffles and pools	A few	Common where there is gravel	A marked paucity only in most recently dredged portions
<i>Poecilichthys speculabilis</i> Agassiz Orange-throated Darter	One specimen?		The <i>Etheostoma coeruleum</i> Storer of Meek was either <i>P. coeruleus</i> or <i>P. speculabilis</i>	Uncommon	Common or abundant in undisturbed portions			A prairie-stream species; may have invaded Lost Creek with the draining of Black Swamp
<i>Etheostoma blennioides blennioides</i> Rafinesque Northern Green-sided Darter					Rare or uncommon, usually frequenting the faster, larger riffles		Rare	Probably a recent invader
<i>Lepomis cyanellus</i> Rafinesque Green Sunfish	Abundant	Abundant		A few	Usually common; sometimes abundant	A few	Usually common, abundant in ox-bows	Most numerous in well-defined pools and ox-bows
<i>Lepomis megalotis</i> (Rafinesque) Long-eared Sunfish	Less abundant than <i>Lepomis cyanellus</i>		Meek probably had <i>L. megalotis</i> (Cope) the form most numerous in the Maumee drainage					Recent collecting indicates that this species is less widespread and less numerous in Ohio section of Maumee drainage than it was in 1893 (Kirsch, 1895: 331)
<i>Pomoxis annularis</i> (Rafinesque) White Crappie					Sixteen specimens, all from deep holes		A few	Both creeks have been repeatedly stocked with this species
<i>Cottus bairdii bairdii</i> Girard Northern Muddler				Rare, usually absent	Abundant in the small streams containing many springs; uncommon in Lost Creek proper			A relict in clear, small brooks; has been recorded only once before in Ohio section of the Maumee drainage (Kirsch, 1895: 332)

## BOOK NOTICES

---

### Weather

The publishers are to be congratulated on the attractiveness of "Weather"—the first of a forthcoming series of popular treatments on natural phenomena by Gayle Pickwell. The story of weather is vividly told in large pictures, supplemented by fascinating writing devoid of scientific terms and formulae. The book is for the layman and is not intended as a textbook for use in a technical course, although it should serve nicely as a supplement in Geography, Meteorology, and Climatology courses. Especially fine are the picture clouds, lightning, dew and frost. The author's enthusiasm for fine pictures has resulted, however, in the inclusion of some subjects remote from the theme of the book. Engraving, printing, and binding are superb.—*Paris B. Stockdale.*

**Weather**, by Gayle Pickwell. x+170 pp. New York, McGraw-Hill Book Company, Inc., 1938. \$3.00.

---

### Heredity for You and You and You

This book is the first attempt at a popular presentation of human inheritance since Popenoe's "The Child's Heredity," published in 1929. The author is a layman in the field of genetics, but is a writer of considerable experience. He is gifted indeed in his ability to present technical material in an absorbing manner, for his book is a gem of writing. He has been assisted throughout by a geneticist, Dr. Morton D. Schweitzer, of Cornell Medical College, so that the book is accurate in most of its details. A delightful series of cleverly drawn diagrams presents the salient facts in striking form. The diagrams tend somewhat towards oversimplification; this is rectified to a certain extent by the accompanying text. It is to be regretted that a book so well done in other respects should contain so many teleological statements. The author's interest and enthusiasm completely capture the reader, and the book will be read as eagerly as any novel. It is highly recommended to those who desire an introductory acquaintance with their own inheritance and that of their fellow men.—*L. H. S.*

**You and Heredity**, by Amram Scheinfeld. xvii+434 pp. New York, Frederick A. Stokes Co., 1939. \$3.75.

---

### Plant Genetics

The new second edition of Sansome and Philp is, in the opinion of the reviewer, the best reference available for teachers of advanced plant genetics. Chapter I contains a review of mitosis and meiosis, and of the various simple types of Mendelian inheritance. Chapter II deals with linkage and the most recent interpretations of chiasmata and crossing over. Chapter III takes up the various theories regarding the constitution of the gene and recent findings relative to position effects. Chapter IV, on Variegation and Chimeras, appears for the first time in the Second Edition. Chapters V, VI and VII are devoted to polyploids, and Chapter VIII is entitled Euploids and Aneuploids. Chapter IX discusses various kinds of chromosomal aberrations under the heading of structural hybridity. Chapter X deals with interspecific hybridization, discussing numerous examples. Chapter XI discusses plant genetics in relation to taxonomy and evolution. An excellent bibliography of the literature on plant genetics is included.

The book is perhaps too technical for a text, even for advanced students of plant genetics. We heartily recommend it, however, for the purpose for which it was primarily intended, a reference for the teacher and the research worker in plant genetics.—*D. C. Rife.*

**Recent Advances in Plant Genetics (Second Edition)**, by F. W. Sansome and J. Philp. xi+347 pp. Philadelphia, P. Blakiston's Sons & Co., 1939.

### Light

The seventh edition of an intermediate text book on light by R. A. Houston will undoubtedly receive the acclaim of many teachers in physics. The new edition has brought the already well established text up to the present time and it contains many new colored plates and much new material.

Part I is substantially unchanged, but Part II contains some rearrangement of material and three new colored plates. In Part III the ultraviolet and infrared spectra are discussed together, the material on the theory of spectra is rewritten and enlarged upon. The Chapter XVII is now devoted to X-rays and photoelectricity. It has to a large degree been rewritten and it contains additional illustrations and plates. A chapter on quantum theory has been inserted and now Chapter XIX contains much new material which was a portion of Chapter XX in earlier editions. In Part IV there are added to the end many new and useful tables. To the many who have come to regard Houston's *A Treatise on Light* as a standard text, the new edition is a pleasant surprise.—*H. H. Nielsen.*

**A Treatise on Light (7th Edition)**, by R. A. Houston. xi+527 pp. London, New York, Longmans, Green and Co., 1938. \$4.50.

---

### Quantitative Analysis

The educational philosophy of this book is contained in the following quotations from the preface. "It has been the aim of the authors, in preparing this work, to apply the principles of Physical Chemistry to the theory of Quantitative Analysis in a detailed and thorough manner. In stressing this point of view, it has not been forgotten, however, that the two other aspects of the subject, namely, technique and methods, play an equally important part in the education of the analyst."

"The order of presentation has been carefully considered and is as follows: (1) precision, (2) weighing, (3) measurement of volumes, (4) neutralization, (5) solubility product, (6) oxidation-reduction, (7) electrodeposition, (8) evolution and measurement of gases, (9) electrical conductance, and (10) photometry." The historical division into gravimetric and volumetric methods has not been employed.

This is an excellent book. It contains a full measure of theory and the techniques and details of the methods of analysis are well done and are accompanied by numerous citations from original papers. At the end of each chapter is a list of problems. There is a special chapter on organic precipitants and solvents and a long chapter on photometry. This last is mostly theory, and seems out of balance with the rest of the book. In the opinion of the reviewer the general techniques and methods of colorimetry and turbidimetry would have been better than so much theory. However, the reviewer heartily commends the book to students of analytical chemistry.—*C. W. Foulk.*

**Inorganic Quantitative Analysis**, by Harold A. Fales and Frederic Kenny. Second edition. xiii+713 pp. New York, D. Appleton-Century Company, Inc., 1939. Price, \$4.00.

---

### Colchicine and Polyploidy

The first paper on the use of colchicine in producing polyploidy in plants was published by Blakeslee and Avery in 1937. Because of the great possibilities, which the use of colchicine promises to the plant geneticist and plant breeder, interest in the nature of colchicine and its effects on plants has become widespread. Within the last two years dozens of articles have appeared dealing with colchicine and artificial polyploidy.

A new pamphlet has been published by the School of Agriculture of Cambridge, which summarizes our present day knowledge of the action and use of colchicine in the production of polyploid plants. A bibliography of the literature on colchicine is included. The pamphlet is a sequel to a former pamphlet entitled "The experimental production of haploids and polyploids." Both pamphlets are valuable references for the plant geneticist and practical plant breeder.—*D. C. Rife.*

**The action and use of colchicine in the production of polyploid plants**, by J. L. Fyfe. Imperial Bureau of Plant Breeding and Genetics, Cambridge, England, 1939.

# THE OHIO JOURNAL OF SCIENCE

---

VOL. XXXIX

NOVEMBER, 1939

No. 6

---

## SOME PRACTICAL CONSIDERATIONS IN TESTING FOR GENETIC LINKAGE IN SIB DATA

L. S. PENROSE

Colchester, England

The detection of an association between two inherited characters in family data has sometimes erroneously been interpreted as evidence of genetic coupling or linkage. To establish linkage an equivalent degree of dissociation between the two characters must be demonstrated in the families where the genes which underlie the characters are in repulsion. It has, for example, been asserted that the coincidence of retinitis pigmentosa and polydactyly in certain sibships may be due to the coupling of two genes, one of which underlies the retinal changes and the other the polydactyly (Cockayne, 1935). This hypothesis will be rendered plausible only when sibships are discovered in which polydactyly occurs in just those sibs who are free from retinitis pigmentosa. Otherwise the most likely explanation is that a single gene is responsible for both abnormalities. If an observed association between two characters is imperfect, as is usually the case, this incomplete concomitance need not be interpreted in terms of crossing over. Variation in the expression of the same gene in different members of a population and even among members of the same sibship is common in human data.

It is of some interest to examine the consequences of different types of association of genetic characters. In the first place, if two characters are due to the same gene, positive correlation is observed whether subjects are chosen within specified sibships or selected at random from the general population. The correlation, moreover, is independent of whether or not a physiological connection between the peculiarities can be traced. This type of association must be distinguished from that due to independent genes which have a racial or local grouping. In Holland (Van Herwerden, 1930), for example, a



positive correlation, likely to be due to racial grouping, was noted between the possession of agglutinin B and dark hair color in the general population. In such instances, although the traits are associated in the general population, there will be no correlation between them within the sibships.

Two characters will be found to be negatively correlated within sibships and also in the general population if they are due to allelic genes. This is because the presence of one allelic gene excludes the presence of any other allele. For example, the fact that blood group AB is found to be much less frequent than it should be on the assumption that A and B are independently assorted is, by itself, strong evidence that A and B are allelic genes. Finally it is possible for the same

TABLE I

RELATIONSHIP BETWEEN TWO CHARACTERS	CORRELATION BETWEEN THE TWO CHARACTERS	
	In the General Population	Within the Sibship
Independence.....	0	0
Due to same gene.....	+	+
Racially grouped.....	+	0
Due to allelic genes.....	—	—
Physiological compensation.....	—	—
Genetic linkage.....	0	+ or —

gene to have effects of a physiologically compensatory nature. Thus, for instance, head shape may vary according to genetic constitution in persons whose head sizes are of the same magnitude: length and breadth of the head may thus be found to be negatively correlated both in sibships and in the general population.

When dealing with the metrical characters which have multiple genetic backgrounds, the possibility of finding conditions which closely simulate linkage in sibships must not be overlooked. If the two characters are totally uncorrelated in sibships the danger of making a mistake is slight. Even so, it is theoretically possible for concomitant and compensatory variations which are not in any way due to genetic linkage to coexist. In Table I the types of association and dissociation which may be mistaken for linkage are set out.

The peculiar feature of genetically linked characters is that they are equally likely to be positively or negatively correlated within single sibships.

The simplest way of testing for genetic linkage between dominant and recessive characters (Penrose, 1935) is to classify all the pairs of sibs in the available data. A  $2 \times 2$  table is compiled in which each pair is entered according to whether its members are like or unlike with respect to the two test characters. A significant deviation from proportionality in such a table can be caused by linkage between the two characters. A similar deviation can also be caused by any of the situations discussed in the paper which give rise to a positive or negative association. These possibilities must therefore

TABLE II

		CHARACTER A		
		Like	Unlike	Total
CHARACTER B.....	Like.....	x	y	x + y
	Unlike.....	z	w	z + w
	Total.....	x + z	y + w	t

always be examined before claiming a positive result in any linkage study.

If the numbers in one or more of the cells in the  $2 \times 2$  table are small, the exact test for significance of a deviation from proportionality can conveniently be applied (Fisher, 1934). An estimate of the recombination value of the two genes can be obtained from the  $2 \times 2$  table by calculating the function  $\phi$ , from Table II, by the following formula

$$\phi = \frac{xw - yz}{(y + w)(z + w)}.$$

If there is no crossing over,  $\phi$  has the maximum value of  $\frac{1}{2}$  with common characters and of  $\frac{1}{3}$  if one or both characters are rare. When there is random assortment,  $\phi = 0$ . The standard error of  $\phi$  is approximately  $\sqrt{1/w - 1/t}$  and so the statistical value of the result depends mainly upon the

number of pairs of sibs unlike for both the characters. Unless the investigator is fortunate enough to obtain a small sample of data in which  $\phi$  happens to have an unusually large value, no significant positive result is to be expected unless more than 100 pairs are classified. If sibships in which one of the characters does not occur are left out of the reckoning, there is no loss of information because these sibships cannot contain any pairs unlike in both characters. In practice it is convenient to select sibships by the presence of a comparatively rare dominant or recessive trait in at least one member; tests for linkage are then made with other traits which are found distributed in these sibships. If the second test factor has a fairly high gene frequency in the general population, the cells  $x$ ,  $y$ ,  $z$  and  $w$  in the  $2 \times 2$  table will all be of the same order of magnitude. In this case significance of a deviation from proportionality can be safely examined by the symmetrical function  $\chi^2$ , by the formula

$$\chi^2 = \frac{(xw - yz)^2 t}{(x + y)(x + z)(z + w)(y + w)}.$$

If the numbers in the four cells are exactly equal in magnitude this test is equivalent to applying Fisher's  $u_{11}$  function to the data.

The method of classifying like and unlike pairs of sibs needs amplification if the data concern characters which have more than two alternative values. Data analyzed by Burks (1937) concerning tooth deficiency and hair color are of this type. Metrical characters can be dealt with by differences in sib pairs (Penrose, 1938); they can also be simplified by choosing a point in the scale so that every individual can be classed as greater or less than a given value. It is not permissible to classify sibs so that unlikenesses of more than one kind are grouped together. With multiple alleles care is also needed. Suppose, for example, that in a certain family there are four sibs, as follows: M, A; N, A; MN, a; and MN, a. Here M and N. represent blood agglutinogens and A is a rare recessive trait. The sibships can be scored for like and unlike pairs for the two characters N and A or for M and A separately. The result is the same in either case (Table III) and correctly indicates free assortment of the characters.

If an attempt is made to group like and unlike pairs without specifying two alternatives and only two, a different distribution is obtained (Table IV). There is now a positive deviation from proportionality. The correct way to compile this table is to

TABLE III

		A	
		Like	Unlike
M.....	Like.....	1	2
	Unlike.....	1	2

TABLE IV

		A	
		Like	Unlike
M, N, or MN....	Like.....	1	0
	Unlike.....	1	4

TABLE V

		A	
		Like	Unlike
MN.....	Like.....	1	0
	One degree of unlikeness.....	0	4
	Two degrees of unlikeness.....	1	0

distinguish between unlikeness of M and N (two degrees) and unlikeness of MN and M (one degree). The table should be a  $2 \times 3$  table (Table V) in which symmetry is again established.

The method of counting like and unlike pairs for characters which can take several alternative values will give rise to misleadingly positive results if uncritically applied.

The search for interrelationship due to genetic linkage between psychological factors has been suggested by Price (1937). The same care is needed in selecting suitable mental factors for testing as in choosing physical characters. Only abilities which are uncorrelated can be rightly chosen for the test. If the simple method of like and unlike pairs is to be used, each sib must be scored for presence or absence of each given quality.

#### REFERENCES

- Burks, B. 1937. Carnegie Inst. Wash. Yearbook, 312-319.  
 Cockayne, E. A., Krestin, D., and Sorsby, A. 1935. Quart. Jour. Med., new series 4: 93.  
 Fisher, R. A. 1934. Statistical Methods, 5th ed. Edinburgh, Oliver and Boyd.  
 Penrose, L. S. 1935. Annals of Eugenics 4: 133; 1938, *ibid*, 8: 233.  
 Price, B. 1937. Psych. Rev. 44: 183.  
 Van Herwerden, M. A., and Boele-Nyland, Th. Y. 1930. Proc. Kon. Akad. Wet. 33: 659.

#### Schizophrenia

The author of this book, while now connected with the New York State Psychiatric Institute and Hospital, was formerly with the Herzberge Hospital in Berlin. While there he made an intensive study of the schizophrenic cases admitted to the hospital during its first ten years of existence. These comprise 1087 proband cases, diagnosed and proved to be schizophrenics beyond the possibility of doubt. In addition there were carefully studied 3279 husbands, wives and parents of these probands, 3384 direct descendants, 3920 siblings and 2194 nephews and nieces. These individuals were as far as possible personally interviewed. The interviews were supplemented by the extensive registry and police records. The results have been embodied in the present book.

Believing that the demonstration of a genetic basis for schizophrenia would not result in a fatalistic nihilism towards clinical therapy and prophylaxis, but rather would put therapeutic procedure on a sound biological basis, the author made a careful genetic survey of his material. He concludes that schizophrenia is dependent upon a recessive factor, with a penetrance of about 70%. The eugenic and clinical implications of these findings are discussed at considerable length. He also concludes that there is a genetic relationship between the tendency to schizophrenia and the heredito-constitutional susceptibility to tuberculous infection, and he further suggests that the common basis for these two predispositions lies in a hereditary functional weakness of the reticulo-endothelial system. Seventy-six tables and many detailed case records make up the body of the book. A glossary and a bibliography are appended.—L. H. S.

**The Genetics of Schizophrenia**, by F. J. Kallman. xvi + 291 pp. New York, J. J. Augustin, 1938. \$5.00.

#### Worm's-eye Viewpoint of Life

This is a simple, straightforward, very informal account of the phenomena of life, told by a biologist renowned for his penetrating researches into heredity and sex-determination. The worm *Ascaris* provides the theme of the story, but only the theme, there being many delightful side-excursions into other regions of the animal world and into the author's personal reminiscences. Almost the book could be recommended as a text. At any rate it should be required reading for all students of zoology. It provides a fresh viewpoint and a personal approach which might well be incorporated into text books.—L. H. S.

**Ascaris: the Biologist's Story of Life**, by Richard Goldschmidt. ix + 390 pp. New York, Prentice-Hall, Inc., 1937. \$3.25.

# A GRANODIORITE STOCK IN THE CASCADE MOUNTAINS OF SOUTH-WESTERN WASHINGTON

W. M. FELTS,  
University of Cincinnati

## CONTENTS

Introduction.....	297
Location.....	298
Drainage.....	298
Topography.....	299
Areal Geology.....	300
Eagle Creek Formation.....	300
Skamania Andesites.....	301
Silver Star Granodiorite.....	302
Petrography.....	304
Petrology.....	309
Geologic Structure.....	312

## INTRODUCTION

The presence of a body of granitic rock near Silver Star Mountain in the Cascade Range of south-western Washington has been known to prospectors and mining men of the region for more than fifty years, but no material on the geology of the immediate region has been published. Allen<sup>1</sup>, in an unpublished thesis, described the granitic rock as a quartz diorite and called the mass "Silver Star Formation" after the highest peak in the area. Any work that may have been done in connection with mining operations within the area is not publicly available.

The aims of the study summarized in the following paper were, in the main, twofold: (1) to map, both areally and structurally, the intrusive and as much of the surrounding rocks as necessary to determine the time and mechanics of intrusion, and (2) to determine the petrographic character and the petrologic history of the intrusive body and its surrounding rocks.

The work was made possible by a grant from the research fund of the Ohio Academy of Science and was greatly furthered by the able work of the writer's field assistant, Mr. R. H. Howe. The co-operation and assistance given by the U. S. Forest Service men of the Columbia National Forest is also greatly appreciated.

<sup>1</sup>Allen, J. E. "Contributions to the Structure, Stratigraphy, and Petrography of the Lower Columbia River Gorge." Univ. Oregon M.A. Thesis, 1932.

Suggestions made, both in the field and in the preparation of the manuscript, by Dr. J. L. Rich have been particularly helpful.

*Location.* The area examined lies in the western portion of the Middle Cascades about twelve miles north of the western end of the Columbia River Gorge. It consists of a rectangle eight miles north-south by five miles east-west, the south-west corner of which is that of Township 3 North, Range 5 East, Willamette Meridian. The area thus described comprises forty square miles, the northern three-quarters of which are within the Columbia National Forest boundaries.

The region may be reached from Portland by U. S. Forest Service roads connecting with the state highway system of Washington at either Hemlock or Yacolt.

*Drainage.* The area is drained by the headwaters of both the Washougal River and the South Fork of the Lewis River. The Washougal is a south flowing stream entering Columbia River near Camas, Washington. The Lewis flows to the west, is joined by the North Fork, and enters the Columbia near Woodland, about thirty-five miles downstream from the mouth of the Washougal. The headwaters of these two streams have dissected the area in a dendritic manner to a mature stage with a relief of from 2500 to 3000 feet. A divide, along which are located the highest peaks of the immediate area, separates the opposing headwaters of the Lewis and the Washougal. This divide trends from the north-east corner of the area in a direction a little west of south to the summit of Bluff Mountain, in section 16, where it turns at right angles and trends east-west to the summit of Silver Star Mountain.

The greatest precipitation occurs in the winter months and is, in the higher portions of the area, frequently in the form of snow which forms enormous drifts in the deeper canyons. These drifts linger till past mid-summer in most years and are largely responsible for the perennial character of many of the smaller streams near the heads of the canyons which would otherwise be without water in the late summer.

Since the destruction of the forest cover in the great fires of 1902 and 1929 the runoff has been much more rapid than formerly. The effects of this increased runoff are shown to best advantage on steep soil-covered slopes by the development of young gullies, and, in some cases, by complete removal of the thin soil mantle. Another noticeable effect is the increased severity of the spring freshets that accompany the warm spring

rains. Quantitative data on this increased runoff can not be obtained as no figures for the precipitation or runoff in the immediate area are available.

*Topography.* As was stated under the heading of drainage, the region is a maturely dissected plateau, largely of lavas, with a relief averaging close to 2000 feet and locally reaching a maximum of 3000 feet. The main divide between the Lewis and Washougal drainage basins attains elevations as great as 4400 feet A. T. and has saddles, where strong opposing tributaries have been active, as low as 2900 feet A. T. The general eleva-

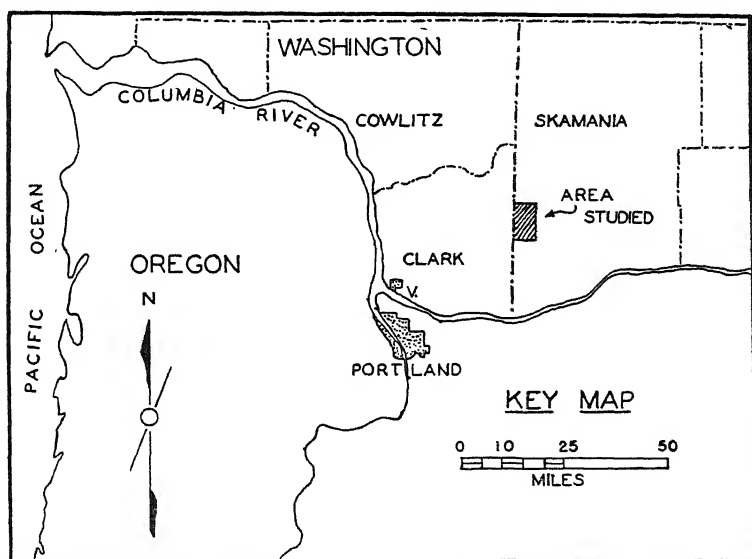


Fig. 1. Location Map.

tion is, however, near 3200 feet A. T. From this main divide branch long steep spurs separating the canyons and the smaller gullies occupied by the individual headwaters. These spurs are very steep, sloping from the elevation of the main divide down to the level where the two streams join; the slopes of the spur crests often are as great as 2000 feet per mile. Their sides are more precipitous, in some cases being vertical cliffs from a few tens of feet up to 1200 feet in height, but more commonly being live talus slopes resting at the angle of repose. These talus slopes, best developed on the granodiorite, cover a large portion of it and are in a few instances more than a mile in length.



At the heads of some of the larger canyons are small cirque-like basins in whose bottoms are depressions as much as seventy-five feet deep and 150 yards in diameter. These are separated from the head of the canyon proper by a rock rim or lip. Often these basins are occupied by small tarns, and snowdrifts persist in a few until late summer. No glacial striae were found on the rock lips; and, consequently, these basins are believed to be the result of erosion by small glaciers, not extensive enough to have moved very far out of their cirques.

The summits of the ridges when viewed from one of the higher peaks exhibit the same strikingly accordant skyline that is evident in the Cascades further north. This accordance has been treated by Willis,<sup>2</sup> Russell,<sup>3</sup> Smith,<sup>4</sup> and others as representing the trace of an old erosion surface called by them the Cascade peneplain. Regardless of whether or not it represents a true baseleveling, this accordance of summits as viewed on the skyline is one of the striking features of the topography of the region.

#### AREAL GEOLOGY

*Eagle Creek Formation.* The rocks of this area fall naturally into three distinct lithologic units. The oldest of these is the Eagle Creek formation (Warrendale formation of Hodge<sup>5</sup> and others) of probable Oligocene age (now considered lower Miocene by Chaney<sup>6</sup>) consisting of volcanic tuffs and breccias, bajada conglomerates, and minor amounts of intercalated andesitic lava flows near the top of the formation. The Eagle Creek is typically exposed in the central portions of the Columbia River Gorge where it has been described by Chaney<sup>7</sup> and Hodge<sup>5</sup> and is also widely exposed in its numerous variations in the greater part of the Washougal basin. This formation outcrops along the eastern margin of the area under consideration, especially good exposures being noted in parts of sections 21,

<sup>2</sup>Willis, Bailey. "The Physiography and Deformation of the Wenatchee-Chelan district, Cascade Range." U. S. G. S. Prof. Paper 19, pp. 41-95, 1903.

<sup>3</sup>Russell, I. C. "A Preliminary Paper on the Geology of the Cascade Mountains in Northern Washington." U. S. G. S. 20th Ann. Rpt., pt. 2, pp. 83-210, 1900.

<sup>4</sup>Smith, G. O. "Contributions to the Geology of Washington: The Geology and Physiography of Central Washington." U. S. G. S. Prof. Paper 19, pp. 9-38, 1903.

<sup>5</sup>Hodge, E. T. "Progress in Oregon Geology Since 1925." Northwest Science 6: 44-53, June, 1932.

<sup>6</sup>Chaney, Ralph W. Personal communication, April, 1936.

<sup>7</sup>Chaney, Ralph W. "The Flora of the Eagle Creek Formation." Chicago Univ. Walker Mus. Cont., Vol. 2, No. 5, pp. 115-181, 1920.

22, and 28 near the headwaters of Dougan Creek. Exposures of the Eagle Creek formation also occur in the canyons of Silver, Bluebird, and Bear Creeks along the eastern margin of the area; but, in these basins, they were not differentiated on the map from the overlying Skamania andesites.

The Eagle Creek as exposed within the mapped area consists mainly of cream colored vitric tuffs which usually weather to a yellow or white colored soil. Varicolored tuffs, usually green or red, are also found as are some greenish and purplish breccias. The tuffs may pass through the complete range of color within a distance of twenty-five feet along the strike. The lack of assortment and usual lack of bedding of any regular nature within these tuffs suggest a subaerial mode of accumulation. At many places, however, the tuffs and breccias have been reworked by streams; and the bedding shows, in these cases, that accumulation was governed by fluvial and occasionally lacustrine conditions.

*Skamania Andesites.* The Eagle Creek beds are overlain by a thick series of andesites among which are intercalated minor amounts of breccia and other pyroclastic material. Within the area the contact is nowhere definitely exposed, although in many places it can be approximated within five feet. East of the mapped area, in the Washougal basin, the andesites overlie the Eagle Creek in places disconformably and in other places with a distinct angular unconformity representing a period of considerable erosion. At still other localities, notably on the east edge of the mapped area the andesites interfinger with the tuffs suggesting at least partial contemporaneity or overlapping of the deposition of the tuffs and the extrusion of the andesites.

These andesites compose the bulk of the country rock into which the granodiorite stock forming the subject of this paper was intruded, and are the most wide spread of the formations within the mapped area. They are in the form of rather thin and extensive flows that were probably extruded in a very fluid form. Locally these flows may have had rather high initial dips, a fact that complicates quantitative determination of later folding. In the lower two-thirds of the series the flows are mildly folded—the maximum dips recorded being about thirty-five degrees. This figure rarely exceeds ten degrees, the steeper dips being noted in only a few places near the contact with the intrusive rocks. The upper third or about 800 feet of these flows, exposed only on the upper portion of Silver Star Moun-

tain, is nearly flat lying, the maximum dips recorded being two degrees in a westerly direction. This upper portion has also suffered less alteration than the lower partially propylitized andesites.

These lavas support most of the steep cliffs within the area, also most of the higher peaks such as Bluff and Silver Star mountains as well as most of the higher portions of the divides. They are the most conspicuous and best exposed rocks in the area and over wide areas in adjacent portions of Skamania County. For this reason the name Skamania is proposed for this series of andesites.

No definite age has been assigned to this series of lavas, but, in the opinion of the writer, they are the probable equivalent of the widespread Keechelus series so prevalent in the Cascades a few tens of miles to the north. This opinion is based on the following facts: (1) the petrographic character of the andesites in the mapped area and that of the Keechelus as described by Coombs<sup>8</sup> and others is very similar; (2) the Columbia River Basalts exposed in the Columbia River Gorge appear to abut against the lower portions of the Skamania andesites; therefore, these andesites, in the lower part, must be pre-Columbia basalt or, in other words, pre-middle Miocene which corresponds with the supposed age of the lower Keechelus lavas as suggested by Warren,<sup>9</sup> and (3) the Skamania andesites are divided in the same manner as the Keechelus into an upper and lower division. As in the Keechelus, the lower division of the Skamania has undergone more folding and metamorphism than the upper division.

Lavas later than the andesites of the Skamania series occur as intracanyon flows in the canyon of the Lewis River four miles west of the area and in the canyon of Wind River a few miles to the east. Those in the Lewis River near Sunset Guard Station have been trenched by the river in a narrow gorge exposing old andesitic and dioritic stream gravels cemented together by the andesite of the late flow. The age of these intra-canyon flows is probably Pleistocene.

*Silver Star Granodiorite.* The third lithologic unit within the area is a stock of granodiorite with subordinate amounts of

<sup>8</sup>Combs, H. A. "The Geology of Mt. Rainier National Park." Univ. Wash. Pub. in Geology, Vol. 3, No. 2, pp. 131-212, 1936.

<sup>9</sup>Warren, Walter. "Tertiaries of the Washington Cascades." Pan-Am. Geologist, Vol. 65, No. 4, pp. 241-247, 1936.

augite diorite and quartz diorite near the borders of the mass. The stock is an elongate body about ten miles long and varying in width from one and one-half to two and one-half miles. Its long axis trends north twenty degrees east. Its walls are very steep as proven by the fact that very deep canyons cutting into the country rock a short distance from the walls do not expose any mappable areas of intrusive rock. Small spots of granodiorite were observed in Star Canyon and in the canyon of Dougan Creek but were not mapped. The southern boundary of the stock, extending to the south for a distance of about a mile, was traced but not in enough detail to be drawn on the map.

This stock cuts the Eagle Creek formation and the lower portions of the Skamania andesites, producing contact metamorphic phases in both formations and sending small dikes and stringers of granodiorite and aplite into both the tuffs and andesites. The upper third of the andesites does not seem to have been intruded by this granodiorite. At least no dikes or other evidences of intrusion cut the upper andesites and they have not been subjected to the degree of propylitization that characterizes the lower portions of the series. It would thus appear that there has been some time interval between the extrusion of the lower and the upper divisions of the Skamania series. During this interval the intrusion of the granodiorite occurred.

Swarms of xenoliths near the contacts with the andesite and larger inclusions of tuffs and andesites in the upper portions of the intrusive rock indicate that stopping processes had a role in the emplacement of the mass. Some of these inclusions are large enough to have been roof pendants of considerable size. These inclusions are quite thoroughly metamorphosed, usually to hornfels.

The granodiorite is strongly jointed—a fact that allows frost action on the high peaks, such as Little Baldy, to rive the outcrops into rhombic and platy fragments with the consequent production of the long talus slopes previously mentioned. Good outcrops occur only in the stream bottoms and occasional cliffs not yet covered by talus. The boundaries of the stock, where drawn in dotted lines, can be approximated within a very few feet; but the actual contact is covered. This lack of suitable outcrops is also responsible for the paucity of structural measurements.

## PETROGRAPHY

*Eagle Creek Formation.* The Eagle Creek formation, as exposed in the area, consists of vitric tuffs usually white or cream colored, and, less commonly, of greenish and reddish hues. The color, in most cases, seems to depend upon the character of the oxidation of the iron compounds within the glass at the time of formation. The material composing these tuffs ranges from partially kaolinized shards less than 0.05 mm. in diameter to coarse fragments of vesiculated pumiceous material up to three inches in diameter. This pumiceous material has been indurated and made resistant by compaction and cementation. The cement in the majority of cases is silica, although enough kaolin is present in most cases to also act as a cement.

In places where the tuffs have been subjected to hydrothermal solutions emanating from the intrusive body they have been entirely replaced by silica forming a very resistant quartz rock in which are preserved the shard structures of the original tuff. Good outcrops of this silica rock occur in the low saddle in section 21 just south of Bluff Mountain.

*Skamania Andesitic Series.* The rocks composing this series consist, in the main, of gray porphyritic andesites with subordinate amounts of tuffs and breccias. The pyroclastics are petrographically very similar to the coarser phases of the Eagle Creek, possibly a little more pumiceous.

The andesites of the lower portion of the series are characteristically gray or greenish-gray in color and are nearly always porphyritic, the phenocrysts being striated grayish-white feldspar. The flows in this portion are usually much jointed with epidote and other minerals frequently developed within the joint cracks.

Examination of thirty-five slides from the lower portion of the andesite series brings out the following general characteristics. All sections examined were porphyritic with phenocrysts of corroded and markedly zoned plagioclase embedded in a pilitic to intersertal and, infrequently, diabasic groundmass of plagioclase laths, granular augite, and anhedral magnetite, together with varying amounts of chlorite and similar minerals developed from the ferromagnesian constituents. The phenocrysts range in size from 1 to 6 mm. and average about 3 mm. in diameter. They are blocky and exhibit a marked tendency

toward a glomeroporphyritic habit. Their composition ranges from An 50 to An 30 with the average being close to An 35. Where zoned the core has the more basic composition. Usually the composition becomes more acid outward with each zone although rarely some reversals of zoning do occur. Small veinlets of orthoclase are developed in fractures traversing these phenocrysts especially in those sections made from specimens taken from close to the intrusive body. Twinning is after the albite, Carlsbad, and pericline laws with all three commonly developed on one individual. These phenocrysts form from 20 to 35 per cent of the rock.

The plagioclase laths in the groundmass vary in size from 0.01 mm. up to 0.5 mm. in length averaging about 0.3 mm. They vary in composition in the various flows from basic to medium andesine and in one of the most basic of the flows are an acid labradorite. Twinning is commonly after albite and Carlsbad laws, pericline twinning being rare. Often these laths are arranged in a marked fluxion structure. These second generation feldspars comprise from twenty-five to forty per cent of the rock.

The ferromagnesian minerals are nearly always altered to chlorite and similar minerals, but, where fresh, are anhedral grains filling the interstices between the feldspar laths. These minerals may be either augite or hornblende—usually augite and in rare cases hypersthene. There may have been considerable amounts of hypersthene in some of the rocks but it has since become chloritized. A very few thin sections show relicts of what were probably hornblende phenocrysts.

The augite of the groundmass occurs as anhedral grains rarely exceeding 0.05 mm. in diameter, is pale yellow in plane light, and sometimes shows a faint pleochroism.  $N_m$  averages about 1.69. This augite makes up 15 to 25 per cent of the rock. Magnetite, in the form of small anhedral grains and dust, is scattered through the groundmass and makes up about ten per cent of the rock. Epidote developed within the plagioclase phenocrysts and chlorite from the pyriboles sometimes totally destroy the former minerals.

The upper division of the Skamania andesites is characterized by fresher rocks of the same general types as those described for the lower division. These rocks are, however, generally more vesicular and in some cases have partially hyaline groundmasses. The rocks are in thin flat-lying flows exposed only on

the upper portions of the main mass of Silver Star Mountain. A few quartz and carbonate veins cut these flows, some of the vesicles are filled with chalcedony or dolomite, and some of the ferromagnesian minerals in the groundmass are chloritized. Otherwise the rocks are nearly fresh as contrasted with the propylitized rocks of the lower division.

Microscopic examination of 15 slides from these flows shows the following characteristics. Except in a few holohyaline flows of little importance all of the flows are porphyritic with phenocrysts of medium andesine averaging about 3 mm. in length. These phenocrysts are hypidiomorphic, exhibit strong zoning, marked corrosion, and a tendency toward a glomeroporphyritic habit. Combined Carlsbad and albite twins are very common. These phenocrysts comprise from 15 to 30 per cent of the rock.

The groundmass consists of a pilitic, intersertal, or, less commonly, a diabasic aggregate of plagioclase laths, anhedral grains of pyroxene and magnetite, and, commonly, small amounts of glass. The feldspar laths range from acid labradorite to medium andesine with basic andesine being the average composition. The pyroxene is usually augite and much less commonly hypersthene. Grains of pyroxene averaging less than 0.03 mm. fill the interstices between the feldspar laths which range from 0.01 to 0.65 mm. in length. The second generation plagioclase comprises from 25 to 40 per cent of the rock, the pyroxene from 15 to 25 per cent, and the anhedral magnetite from 5 to about 12 per cent. Fluxion structure, aligning the phenocrysts and the second generation laths, is usually present and is developed to a marked degree in some of the sections studied.

*Silver Star Granodiorite.* The rock composing this body consists of a mass of granodiorite with subordinate amounts of augite diorite and quartz diorite developed near the periphery of the stock. Aplite dikes and hydrothermal rocks rich in quartz, tourmaline, and sericite are also developed locally within the mass.

The granodiorite is a light colored aggregate of white plagioclase, sometimes tinged pink with the development of orthoclase, clear colorless quartz, and black to greenish biotite and hornblende crystals the color of which depends upon the degree to which chloritization has progressed. In most cases, the minerals can be distinguished megascopically, the grain size often being as large as 6x9 mm.

Microscopically the rock exhibits a holocrystalline granitic texture with the minerals, both light and dark, not uncommonly

aligned in a sub-trachitoid structure. In some instances, the larger plagioclase crystals impart a sub-porphyrific appearance to the rock.

The plagioclase is hypidiomorphic, generally corroded and strongly zoned. The composition of the cores averages basic to medium andesine, each zone becoming richer in Ab to an outer zone of albicase, or, less commonly, albite. Many of these plagioclases have a final rim of orthoclase. This orthoclase also commonly fills fractures developed in the plagioclase crystals. The plagioclase comprises about 55 per cent of the rock.

10 to 25 per cent of the rock consists of interstitial and anhedral orthoclase—in some instances as clear as the quartz, which it closely resembles optically—but more generally “dusty” with sericite.

Clear anhedral quartz shares with the orthoclase the interstices between the earlier formed minerals. The two are commonly intergrown in a myrmekitic intergrowth showing contemporaneity of crystallization. The quartz granules average from 0.5 to 1.2 mm. and make up from 10 to 25 per cent of the rock.

The dark minerals may be uralitized pyroxene, or, more commonly, hornblende or biotite with varying amounts of chlorite and secondary dusty magnetite. A little subhedral magnetite was developed early. These dark minerals are crowded into the interstices between the plagioclase feldspars and make up about 10 per cent of the rock. The biotite, where developed, is a lustrous black variety with 2V estimated at about 5 or 6 degrees and is strongly pleochroic, the formula being X pale yellowish brown, Y reddish brown, and Z very dark brown to black. Inclusions of apatite and of titanite are developed in the plagioclase and to a lesser extent in the quartz.

The more basic phases, as exposed at many places near the walls of the stock are characterized by more lath-like plagioclase crystals, little or no quartz and orthoclase and larger amounts of pyroxene, usually augite. The plagioclase is ordinarily basic andesine. These more basic rocks make but a very small percentage of the total in the stock. Intermediate between these and the true granodiorite is a diorite very similar to the more basic diorite but with 5 to 12 per cent quartz and a little orthoclase.

Aplite dikes developed at a late magmatic stage are composed almost entirely of quartz and pink orthoclase with very small amounts of biotite and of sulfide minerals. Myrmekitic inter-



growth is common and the orthoclase is commonly sericitized or even kaolinized to a considerable extent.

*Metamorphic Rocks.* The metamorphic rocks in this area are all products of thermal or hydrothermal processes accompanying the intrusion of the stock. The thermal metamorphism at places along the contacts between the stock and the andesites produces hornfels of sugary grained recrystallized feldspar, augite, and magnetite, with considerable quartz being introduced in some instances. Where this action has been less severe at a distance from the contact, relicts of the original minerals remain, and the hornfels is very poorly developed. At a greater distance the effects become less marked, until, at a distance varying from a few feet to several hundred, the only effect has been a propylitization of the andesites. This propylitization consists, in the main, of the development of epidote and chlorite within the andesites and the introduction of large amounts of pyrite and quartz. The replacement of the tuffs in the Eagle Creek formation by silica was mentioned previously.

Other hydrothermal effects, both within the intrusive and in the wall rocks, consist of (1) epithermal quartz-sulfide veins carrying low values in base metals and small amounts of gold, (2) quartz-tourmaline-sericite replacements occurring in shatter zones and as small veinlets in the granodiorite, and (3) silicification and orthoclasization of areas in the granodiorite apparently after consolidation of the mass.

The genesis of the ore deposits within the area is being studied and reported in a separate paper by the writer's colleague, Mr. R. H. Howe.

The tourmaline-quartz replacements are shown to best advantage in the large shatter zone shown on the map as crossing sections 33 and 34. Solutions rich in boron and silica have bleached the granodiorite and produced a luxullianite rock consisting of quartz, schorlite, and sericite. In some instances, the tourmaline aggregates make up 90 per cent of the rock. Small veinlets of tourmaline in bleached and silicified portions of the granodiorite occur at the mouth of Summit Creek. The tourmaline is of the schorlite variety;  $N_m$  being 1.66 and the pleochroic formula X pale brown, Z greenish-black. Basal sections show a very marked zonal growth.

The granodiorite in certain areas within the stock, such as in the north-east portion of section 8 and in the north-central portion of section 21 (in the south part of the area) appears pink in the hand specimen and has a dearth of ferromagnesian min-

erals. The original granodiorite, in these instances, shows evidence of having been replaced by orthoclase and quartz after consolidation of the granodiorite. Remains of some of the original minerals and structures of the normal granodiorite have been observed in a number of thin sections made from this altered rock. It is believed that this rock represents a result of orthoclasization after the main mass had consolidated, the potash and silica being introduced either by hot waters or by gaseous emanations.

#### PETROLOGY OF THE STOCK

Field observations and examination of about fifty selected thin-sections from the stock shows a distinct gradation in the body from a quartz-free dark colored augite diorite, occurring at places near the borders, to a granodiorite, approaching a quartz monzonite in composition in the more central portions of the stock. No distinct zoning occurs and, in places, the more acid portions of the stock are in direct contact with the wall rocks, but, in a general way, it may be said that the dioritic phases are definitely border phenomena.

If the original magma at the time it was intruded had had the composition of a quartz diorite, it could form a series ranging from augite diorite near the borders to the quartz-orthoclase aplite dikes developed at a very late magmatic stage by the process of fractional crystallization. If, however, a magma with a composition essentially that of a granite was intruded into a country rock consisting mainly of andesite by processes involving stoping and assimilation, a similar basic border could also be produced.

Samples taken from the acid central portion in section 33 and from the wall phase in section 16 for chemical analysis resulted as follows:

	ACID PHASE	BASIC PHASE
SiO <sub>2</sub> .....	65.90	58.07
Al <sub>2</sub> O <sub>3</sub> .....	15.72	16.54
FeO.....	3.05	4.26
Fe <sub>2</sub> O <sub>3</sub> .....	1.11	2.47
TiO <sub>2</sub> .....	.45	.61
MnO.....	.06	.17
CaO.....	4.78	7.32
MgO.....	2.39	4.94
K <sub>2</sub> O.....	1.94	1.34
Na <sub>2</sub> O.....	3.62	3.32
H <sub>2</sub> O (—105C).....	.16	Nil.
H <sub>2</sub> O (+105C).....	.76	.70
CO <sub>2</sub> .....	Nil.	Nil.
P <sub>2</sub> O <sub>5</sub> .....	.11	.12

F. H. HERDSMAN, Analyst, Glasgow, Scotland.

These analyses were plotted on a diagram with the analyses of the Mount Stuart and Snoqualmie granodiorites published by G. O. Smith<sup>4</sup>, an augite diorite from Bohemia, Oregon, and a granite from Nimrod, Oregon, published by Buddington and Callaghan<sup>10</sup>. All of these analyses are from intrusives of a nature similar to the Silver Star stock, in the same belt in the Cascade Mountains, and probably nearly of the same age. A fairly representative variation diagram for the Cascade intrusives of this type was obtained (Figure 2). The alkali-lime index for the series of analyses used in this diagram is 62.5 which compares with 61.6 reached for the Cascade intrusives of Oregon by Buddington and Callaghan.<sup>10</sup> This number definitely places these rocks in the calcic group as defined by Peacock.<sup>11</sup>

If the dioritic border be taken as an early roof or wall phase in the crystallization of the stock then the course of differentiation within the mass can be shown chemically by the diagram. The curves for the decreases in magnesia, iron, lime, and alumina, as well as those for increasing potash and soda with increasing silica follow the same trends for the stock as for the whole Cascade region. This chemical change is shown mineralogically by the increase in the acidity of the feldspars from basic andesine in the dioritic border phases to albicase and even orthoclase in the granodiorite, by the development of relatively large amounts of free quartz in the more acid phases, and by the change from the pyroxenes of the diorites to the smaller percentages of amphibole and biotite in the granodiorite. The feldspars are almost always zoned with the cores having the more basic composition. This fact shows that in all phases of the stock the early formed crystals were removed from the reacting system by the formation of a more acid zone. As these basic cores were prevented from reacting with the remaining liquid, an acid differentiate would thus be formed.

Xenoliths in all stages of assimilation were noted at many places near the borders of the stock. These range with distance from the contact from angular blocks of fresh andesite to barely discernible ghosts made visible by concentrations of hornblende needles. The andesite clearly has been assimilated by reaction

<sup>4</sup>*Op. cit.*

<sup>10</sup>Buddington, A. F., and Callaghan, Eugene. "Dioritic Intrusive Rocks and Contact Metamorphism in the Cascade Range of Oregon." *Am. Journal of Science*, 5th ser., Vol. 31, pp. 421-449, June, 1936.

<sup>11</sup>Buddington, A. F., and Callaghan, Eugene. *Op. cit.*

<sup>11</sup>Peacock, M. A. "Classification of Igneous Rock Series." *Jour. Geology*, Vol. 39, pp. 54-67, 1931.

with the invading magma and the possibility exists that some of the border phases could be the result of contamination of a much more acid magna. Such contamination would of necessity be a localized phenomena and would not greatly effect the course of differentiation within the stock.

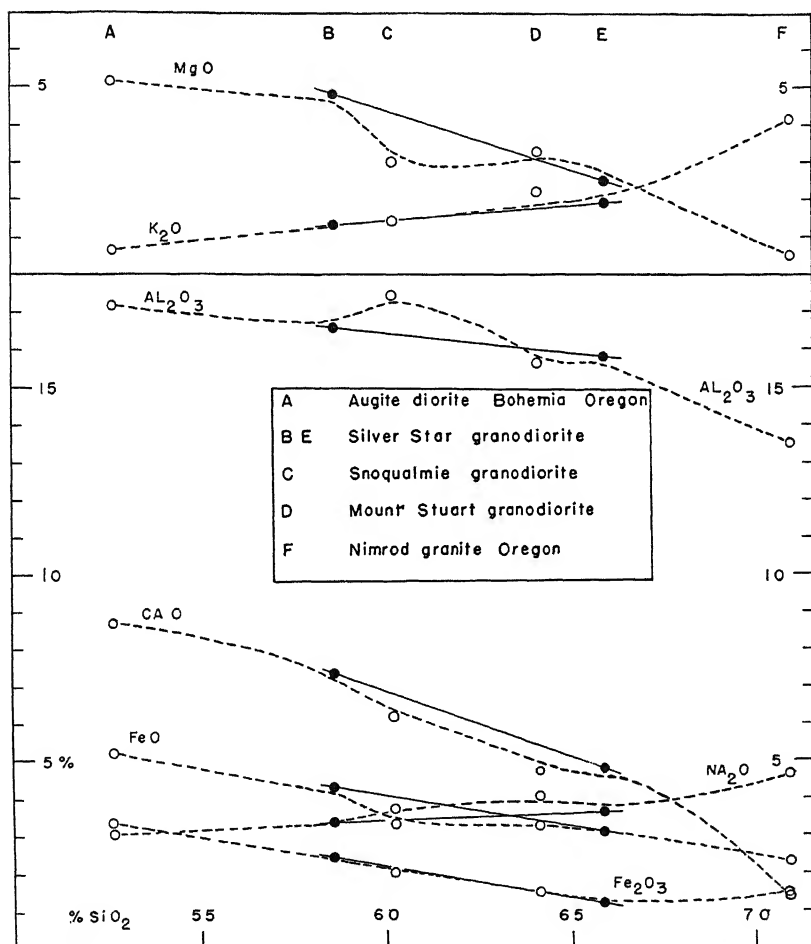


Fig. 2. Variation Diagram for some Cascade Intrusives.

At many places where the basic border of the intrusive is absent the more acid phases are in sharp intrusive contact with the andesite wall rocks. It is believed that at these points portions of the roof including the basic border were stoped into the still liquid acid differentiate and foundered.

## GEOLOGIC STRUCTURE

An attempt was made to determine the mechanics of emplacement for this stock using some of Cloos' methods as outlined by Balk.<sup>12</sup> Although a number of measurements were obtained, suitable exposures are so few and so many of these exposures, especially away from the walls, are of so nearly structureless rock that the interpretation of these data should be taken as only suggestive. Although available data were taken from all exposures in the area, so much of the granodiorite is covered by talus that the structural observations necessarily appear somewhat sketchy.

Elongation within the mass is shown in a few places by schlieren, and, less frequently, by a linear parallelism of mineral grains. The best developed of these lineal features occur near the walls and trend parallel or nearly parallel with the local trend of the contacts. The few observations obtained in the central portions of the mass show a rather consistent east-north-east trend varying from north 60 east to north 80 east.

*Primary Flow Layers.* In a few places along the borders of the mass some of the more resorbed xenoliths and their reaction minerals, principally hornblende, are drawn out in long streaks (schlieren) that are roughly parallel to the walls of the stock. These streaks, in places, form well developed flow layers the strike and dip of which can be measured, but in no case was a consistent pitch of the elements within these streaks apparent. In the north-west corner of section 33 along the Yacolt-Hemlock road a well defined system of streaks and platey structure dips 76 degrees N30W, and in the north-east quarter of section 16 a similar system, less perfectly developed, dips 45 degrees S80E. In both cases, these flow layers dip at rather steep angles away from the stock and under the wall rocks.

In the interior of the stock poorly developed schlieren and elongated inclusions were noted just west of the center of section 4 in the bed of Copper Creek. These layers dip 20 degrees N10W. This last measurement was taken one-half mile east of the west wall of the stock.

*Mineral Parallelism.* In most of the exposures of the granodiorite the nearly equidimensional character of the mineral grains precludes any development of marked mineral align-

<sup>12</sup>Balk, Robert. "Structural Behavior of Igneous Rocks." Geol. Society Am. Mem. 5, 1937.

ments. However, in places near the walls and near the flow layers mentioned above there exists a linear parallelism of

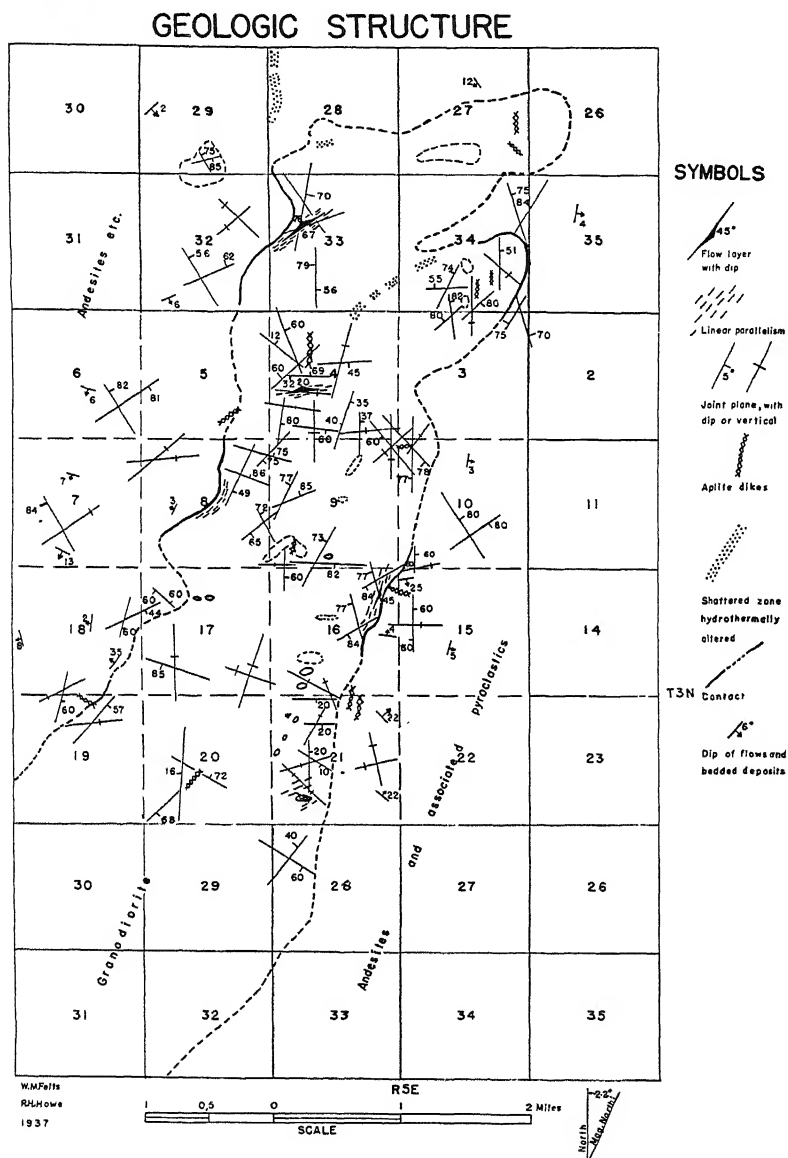


Fig. 3. Structural Map.

mineral grains, both light and dark, but principally lines formed by the alignment of hornblende needles from the more resorbed

xenoliths near the contacts. The general strikes of these lineal elements are shown on the map near the schlieren noted above and also near the center of section 8 and in the south-west quarter of section 21. In most cases no pitch or dip could be obtained for these linear elements, although those in sections 8 and 16 seem to pitch to the south at high angles.

As was the case with the flow layers, an inspection of the map will show that two principal trends exist. Near the walls the strike of the flow layers and of the mineral parallelism is roughly parallel to the walls, but in the more central portions of the stock the trend swings to the east-north-east.

*Joints.* Wherever the granodiorite is exposed, in cliffs and in the stream beds, the joints are plentiful. The more persistent of the joint systems, both within the granodiorite and within the wall rocks, are shown on the accompanying map. Within the intrusive there are no extensive well defined systems of joints such as are commonly found in many intrusives which were intruded under pressures great enough to greatly deform the wall rocks. Instead the joints seem to be governed by purely local factors.

Not enough flow structure exists to designate any of the joint systems as "cross joints," but it is worthy of note that a weak general system of tension joints prevails. This system trends approximately parallel with the long axis of the intrusive. The joints in this system are usually vertical or high angle and are frequently filled with aplite dikes. Since they cross the flow lineations that exist in the central portions of the stock at rather high angles, and, since they are followed by the aplitic dikes, they are probably weakly developed cross joints. Near the borders where these joints follow the same trends as the flow structures they would be classed as longitudinal joints. In any case, these high angle joints trending parallel to the walls of the stock indicate a weak doming.

Near the walls of the stock appear sets of gash fractures usually dipping into the intrusive at varying angles and commonly filled with aplite dikes. These fractures are attributed to friction between the wall rock and the moving mass of the intrusive.

Definite sets of conjugate joints exist (1) near the borders of the stock both in the granodiorite and in the country rock, (2) in the wall rocks at a considerable distance, usually from one-half to one and one-quarter miles from the contact, and (3) scattered within the intrusive mass.

Joint systems of the first type intersect at sharply acute angles and are believed to be the result of frictional drag between

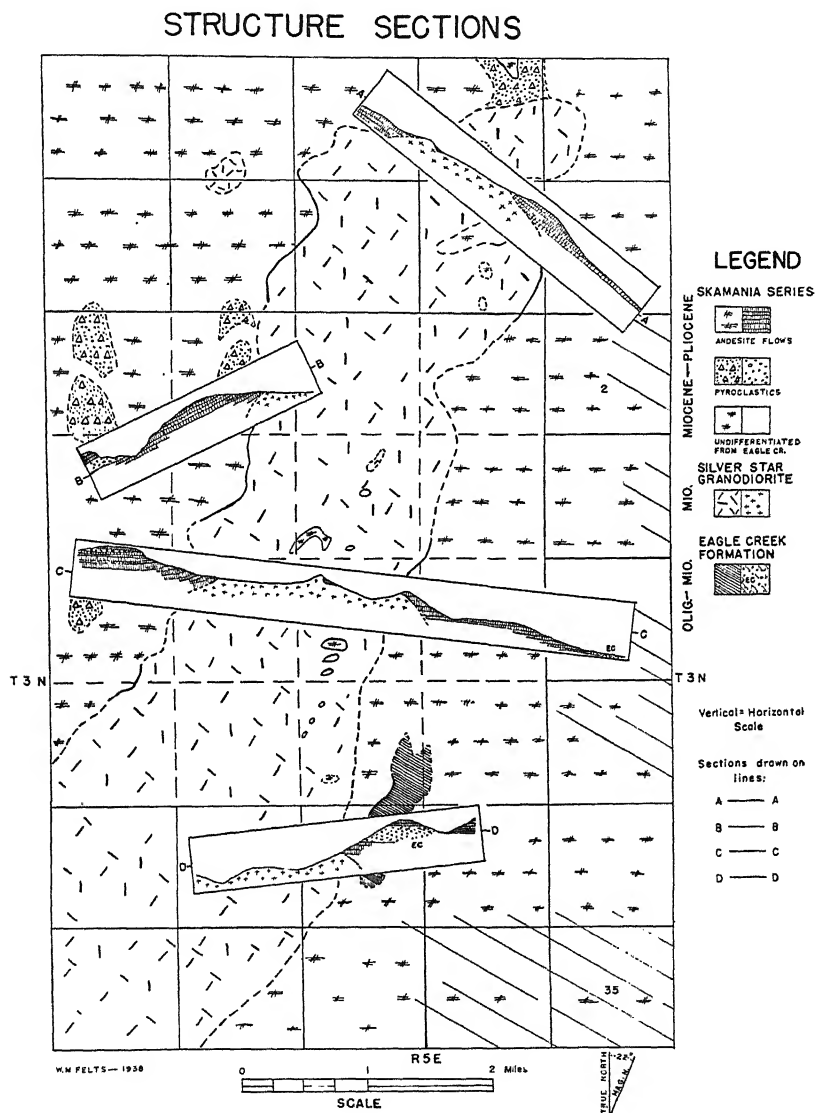


Fig. 4. Structural Sections.

the moving intrusive and the wall rocks. The conjugate joints of the second type intersect at nearly right angles and are believed to be the result of shear due to an almost horizontal



thrust away from the intrusive during emplacement. Conjugate systems of the third type within the granodiorite do not conform to any single system and are probably best assigned to cooling strains. Some of these latter joints are actually faults of small displacement offsetting aplite dikes which fill previously formed longitudinal joints.

In the north-west corner of section 17, and in the north-west portions of section 15 and adjoining portions of section 10 are systems of conjugate joints with a common strike and with dips of 60 degrees to each side. These joints are interpreted as shear planes developed in rigid brittle andesite. Under such conditions, Hartmann's law may be applied to their analysis and the direction of maximum compressive stress would then be determined by a line normal to the line of intersection of the two joint planes and contained in the plane bisecting the acute dihedral angle between the joint planes. In the case of these conjugate joints the direction of this force was vertical.

*Conclusions.* The above data are believed to indicate that the stock was intruded along a line trending approximately N20E. The lack of serious deformation in the wall rocks and the lack of well defined flow structures and joint systems within the mass of the stock suggest that doming and thrusting aside of the country rock was secondary to stoping in the processes of emplacement, at least in the now visible portions of the stock.

The swarms of xenoliths near the contacts many of which are almost completely resorbed are direct evidence of stoping and assimilation. Just what proportion of the total displacement this process represents is not clear.

The flow layers, where noted, tend to arch toward the center of the stock, the systems of steep joints trending parallel to the long axis of the stock can be interpreted as indicating a weak doming, but analysis of the flow structures and joint systems fails to produce any consistent results. It is believed that this relatively small and shallow intrusive was emplaced principally by stoping processes, at least in its visible portions, with consequent local development of flow patterns and joint systems. Under such conditions the determination of the mechanics of emplacement by the methods of Cloos and Balk becomes much less reliable than in deeper seated bodies intruded under greater confining pressures, under conditions where stoping has not played an important part.

# TILLITE AND VARVED SLATE ERRATICS IN NORTHERN RICHLAND COUNTY, OHIO

GEORGE W. WHITE,  
University of New Hampshire

## INTRODUCTION

Most exposures in Ohio of the Wisconsin till show it to be only moderately pebbly and cobbly, with only occasional boulders. At a few places, however, over areas of one to several square miles, unusual concentrations of cobbles and boulders are evident, both in the till and on the surface. One such concentration is in Blooming Grove Township, northern Richland County, northeastern part of Crestline quadrangle (Fig. 1), where the drift is unusually bouldery and the surface of some fields is so covered with boulders that, as in New England, the boulders must be cleared away before the fields can be plowed. Boulders, which have been dragged out of the fields, are piled up in rows along the fences, roads, and gullies and in one case a stone wall has been built around a barnyard.

Most of the boulders in the drift in Ohio are granite or granite gneiss, but near Rome, in Blooming Grove Township, a high percentage are banded slate. Two tillite boulders were discovered three-fourths mile east of Blooming Grove Township, in Cass Township. Both of these localities lie within the Wabash moraine (Leverett, Pl. 13; White, p. 36), just east of the divergence of that moraine from the more northerly Ft. Wayne moraine.

## THE TILLITE BOULDERS

The conglomerate boulders are located one and one-fourth miles southeast of Shiloh, in northwest Section 13, Cass Township, one-fourth mile south of Planktown. They lie at the southeastern corner of a barnyard, at the west edge of State Route 613, 200 feet north of the small stream which crosses the road. The position is shown in Fig. 2.

One boulder (Fig. 3) which lies on the highway right-of-way is 46 inches in the longest dimension and 36 inches in the shortest. It is irregular and subangular to subround in shape. It is made up of particles from 4 inches to sand grain size,

loosely packed, the spaces filled with fine grained crystalline material. The pebbles, which are subangular to subround, are of pink granite, gray granite, pink granite gneiss, gray granite gneiss, vein quartz, greenstone, and dark greenish schist. The matrix is fine grained: in part, dark blackish green material,



Fig. 1. Index map showing location of Blooming Grove Township, Richland County.

now probably mainly chlorite and other ferromagnesian silicates; and in part a crystalline material resembling fine grained arkose.

The second boulder lies 18 feet south-southwest of the first, just outside the line of highway right-of-way. It appears to be more than half underground, but the visible portion measures

58 by 42 inches. It has the same composition as the first boulder, except that its cobbles are smaller and the proportion of matrix higher.

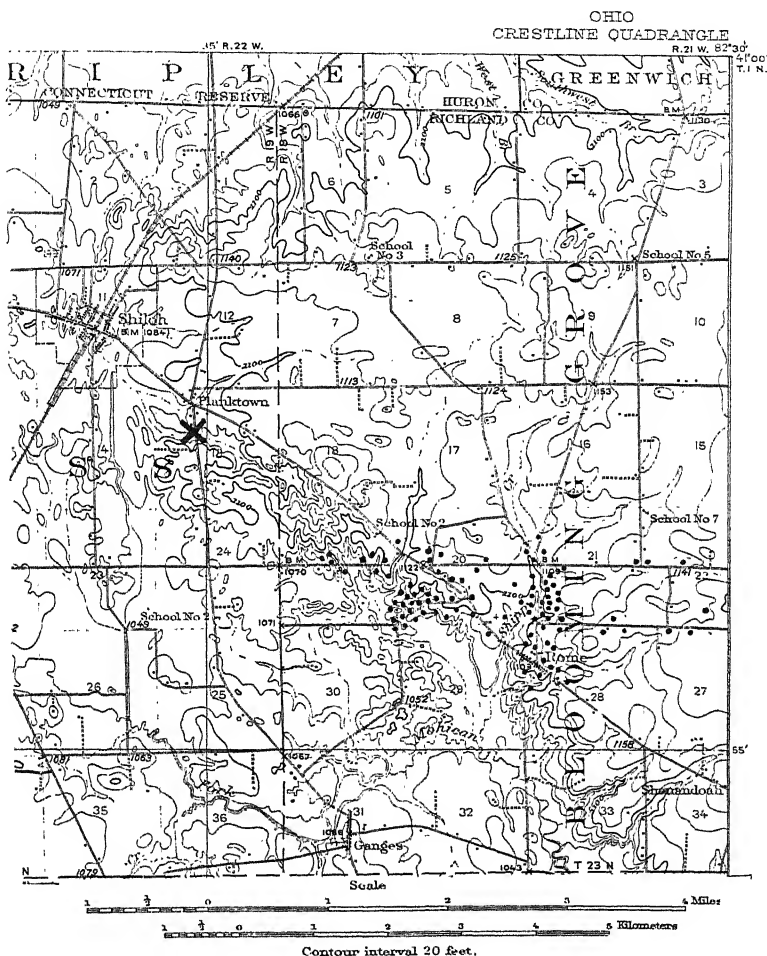


Fig. 2. Northeastern part of Crestline quadrangle. Dots show relative concentration of varved slate erratics. Cross shows location of tillite boulders.

Two almost rectangular blocks of banded slate similar to those concentrated farther east lie between the two tillite boulders. One is 20 by 24 by 15 inches, the other 8 by 10 by 7 inches. The slate is made up of alternating thin dark and light bands. The slaty cleavage is parallel to the bedding planes.

To identify definitely two isolated boulders far removed from original relationships as tillite is difficult or impossible but the writer here interprets them as consolidated ancient (Precambrian) till. The material resembles that of the Squantum tillite, near Boston, Massachusetts, and appears to resemble the Cobalt tillite as described by Coleman (pp. 220-226).

Other boulders of conglomerate which have been interpreted as Precambrian tillite have been found at various places within the drift in Ohio. A large tillite boulder lies in front of Orton



Fig. 3. Tillite boulder on west border of State Highway No. 613, in northwest Section 13, Cass Township, one-quarter mile south of Planktown.

Hall, Ohio State University. Dr. Wilber Stout, state geologist, has preserved in his garden fireplace a small tillite boulder which was dug from the drift in Clintonville (North Columbus). The late Professor Richard C. Lord discovered a large tillite erratic three miles southwest of Gambier, in Pleasant Township, Knox County, about 300 yards west-northwest of the 1194 roadfork which is one-half mile northwest of Graham School. Tillite boulders, while very uncommon in Ohio drift, have been found at widely separated intervals over the state. Professor J. Ernest Carman (personal communication, 1938) estimates that he has seen approximately twenty tillite erratics in his field work in Ohio.

## SLATE ERRATICS

A marked concentration of slate erratics occurs in Blooming Grove Township in the vicinity of Rome, as shown in Fig. 2. The spacing of the dots in Fig. 2 shows the relative density of the slate erratics, each dot representing many erratics. The slate is present in all sizes from pebbles to blocks three feet long. Many of the pieces are beautifully striated on one or more sides, but they are mainly rectangular, and show very little

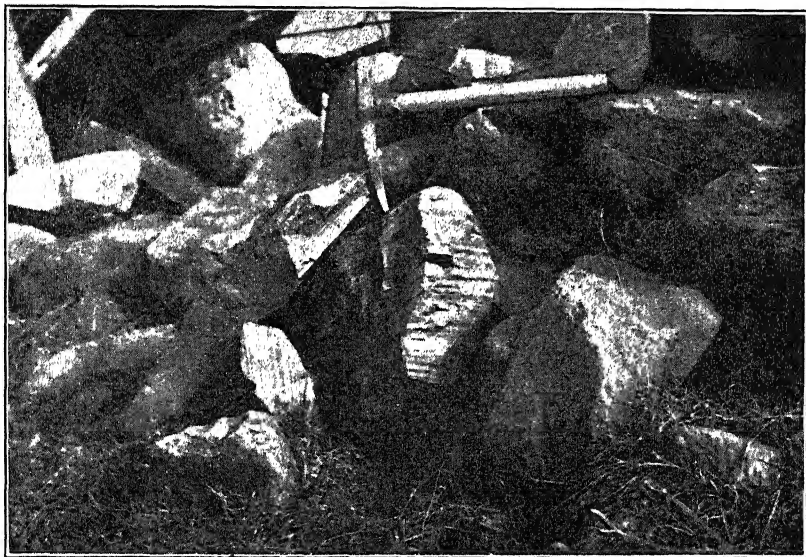


Fig. 4. Varved slate and igneous erratics in pile at edge of field, southwest Section 20, Blooming Grove Township.

rounding. In this area the slate is so common that it has been used for flagstone walks and for a few walls.

The slate is banded, with alternating black and light gray, straight, even bands (Fig. 4). The light bands are the coarser, in a few specimens being almost a fine grained quartzite, indicating that the original material was silt, and not clay. The thickness of the light bands in various pieces varies from the thickness of a sheet of paper to a half inch. The dark bands are very fine textured, the thickness varying from a sixteenth to a quarter inch. In some blocks slaty cleavage is well developed, often parallel to the bedding planes.

This slate is believed to have been originally varved clay and silt laid down in Precambrian glacial lakes, probably upon till which later became tillite. The coarse, thicker layers were laid down in the summer (Antevs, pp. 1-6): the darker, finer, thinner layers in the winter. After deposition, the ancient glacial material was compacted and metamorphosed. Such banded slate, in close relationship to tillite, is known to outcrop in Ontario and Quebec (Coleman, p. 234).

#### SOURCE

All igneous and metamorphic erratics in Ohio must necessarily have been brought from Canada by the Wisconsin or earlier ice sheets. The main area of Cobalt tillite lies in Ontario (Coleman, p. 225) too far west to be the point of origin for the boulders in Richland County, but the small area of Cobalt series at Lake Chibougamau in Quebec (Coleman, pp. 224-225), which lies approximately northeast of Richland County, is not an impossible source for these boulders. As Coleman points out, the centers of the "Labrador" ice sheet were in northern Quebec, east of James Bay (Coleman, pp. 16, 17, map p. 22). The farthest east outcrop of Huronian tillite is east of a line drawn from "Labradorean" centers 2 and 3 (Coleman, map p. 22). Therefore the tillite boulders in Ohio could have come from known Canadian outcrops. Since varved slates are associated with many known tillite outcrops it is quite likely that the tillite and varved slate erratics were brought to Ohio from the same Canadian locality.

The writer wishes to point out only a possibility that the erratics herein described are from Cobalt rocks, not to press the probability of such an origin.

No explanation of unusual concentrations of erratics in restricted localities is entirely satisfactory. Some concentrations may be due to the breaking up in the last part of the transportation process of a single huge erratic. Welford (pp. 362-367) describes an erratic containing 225,000 cubic feet of limestone in the Illinoian till near Oregonia, Warren County, which was carried at least several miles. If this huge erratic had been carried farther it might have broken into smaller pieces, thus giving a concentration of smaller limestone erratics at some locality. Large limestone erratics in Columbiana County are described as transported from another county (Stout and Lamborn, p. 47). The Niagaran limestone erratics

concentrated in a small area in southeastern Morrow County, shown the writer by Professor Lord, may be parts of a single huge erratic which was broken up not far away. That the concentration of slate erratics in northern Richland County may be due to the breaking up of a single huge slate erratic, not far north of the present slate location, is an hypothesis that must be considered.

#### REFERENCES

- Antevs, Ernst.** "The Recession of the Last Ice Sheet in New England." Am. Geogr. Soc. Research Series No. 11. 1922.  
**Coleman, A. P.** "Ice Ages Recent and Past." New York. 1926.  
**Leverett, Frank.** "Glacial Formations and Drainage Features of the Erie and Ohio Basins." U. S. Geol. Survey Mono. 41. 1902.  
**Stout, Wilber, and Lamborn, R. E.** "Geology of Columbiana County." Geol. Surv. Ohio Bull. 28. 1924.  
**White, G. W.** "The Powell and Broadway End Moraines." Am. Jour. Sci., Vol. 30, 1935, pp. 33-44.  
**Wolford, J. J.** "A Record Size Glacial Erratic." Am. Jour. Sci., Vol. 24, 1932, pp. 362-367.

---

#### For the Plant Physiology Laboratory

This book is similar to the first half of the same authors' *Methods in Plant Physiology*. The material of the earlier book has been slightly condensed and in part revised, in order to adapt it to the laboratory part of elementary or intermediate courses in plant physiology. The 167 experiments described are mostly well selected and well planned. The book will be useful both as a laboratory text and as a reference for teachers of plant physiology, general botany and biology.—*B. S. Meyer.*

**Experiments in Plant Physiology**, by W. E. Loomis and C. A. Shull. 213 pp. New York, The McGraw-Hill Book Co., 1939.

---

#### Lifebelts

Readers of Eric Temple Bell's previous books will need no introduction to his pungent stimulating style. In typical Bell manner, he examines in this book the various devices in which man has from time to time lodged his faith. Acting as "neither judge nor jury," but merely as a guide," Dr. Bell with penetrating insight takes up in turn erstwhile life-belts, including, among others, religion, government, righteousness and justice (twin life-belts of the middle ages), internationalism, and science. Needless to say, the discussion is clear, witty and altogether intriguing.  
*L. H. S.*

**Man and His Lifebelts**, by Eric T. Bell. viii+340 pp. Baltimore, The Williams and Wilkins Co., 1938. \$3.00.

---

#### Medicine in Many Languages

This book should be the answer to the prayers of many physicians, public health officers and nurses. It contains a carefully selected list of medical words in English, followed by their translations into German, French, Italian and Spanish. The vocabulary is extensive, and appears to be fairly complete from the medical and social workers' standpoint. Following the vocabulary there is presented a series of medical phrases, with translations, in the form of questions, requests and commands which will be found useful in bedside technic and in army medical work.—*L. H. S.*

**Medical Vocabulary: English, German, French, Italian, Spanish**, by Joseph S. F. Marie. ix+358 pp. Philadelphia, P. Blakiston's Son and Co., 1939.



## FIVE NEW GENERIC NAMES IN THE CHALCIDOIDEA (AUSTRALIA)

A. A. GIRAULT

While completing a systematic Monograph of the Australian Chalcidoidea, the following new genera have been discovered. I take the opportunity also to propose a few new names of species. The group is Hexapoda Hymenoptera.

### **Leptospermophila** new genus

Sphegigasterine Pteromalidae. Like *Parapterosemoidea* Girault but the antennae with two ring-joints, the parapsidal furrows not complete (extending a half way from cephalad), the propodeum bears a distinct neck, a long complete lateral carina, a foveate sulcus from the minute, round spiracle and a median carina which forks a half way down from the base of the part, each fork proceeding to the lateral carina near apex. Marginal vein shorter, slightly exceeding the elongate stigmal, slightly shorter than the postmarginal. Segment No. 2 of the abdomen somewhat exceeding the third segment, combined the two occupying half of the surface of the abdomen. Scrobes united, forming an obtuse, parallel-sided channel to the median ocellus. Lower face deeply incised just laterad of the clypeus, the latter very wide, composed of two wide lobes separated by a median notch and each lobe with a median emargination. Petiole somewhat longer than wide.

### **Leptospermophila fauna** new species. Genotype.

Aeneus, the wings clear. Scape, petiole, knees, tibiae and tarsi yellow, the venation darker. Pedicel short but exceeding the first funicle segment which is square, the rest of the funicle segments widening distad, the last of them distinctly wider than long. Flagellum yellowish. Sculpture usual. A female specimen collected by Henry Hacker from the flowers of *Leptospermum flavescens*, Oxley, Queensland, September 24, 1916.

### **Magellanana** new name

For *Blatticidella* Girault, 1923, October, preoccupied by *Blatticidella* Gahan and Fagan, 1923 (March; or according to Zool. Record, April).

*Magellanana aereitibiae* (Girault). Named for the explorer Magellan. Encyrtidae.

### **Grantanna** new name

For *Neocentrobia* Blood (1925, Ann. Rep. Proc. Bristol Nat. Hist. Soc., (4), 5:254) not *Neocentrobia* Girault, 1912. Named for Gen. U. S. Grant. Trichogrammatidae.

**Coccidoxenus magellani** new name.

For *Coccidoxenus (Tetracnemella) australiensis* Girault, Memoirs Queensland Mus., 1915, 4: 170. Preoccupied by *Coccidoxenus australiensis* (Girault).

**Pleistodontes mayri** new name.

For *Pleistodontes froggatti* Grandi, 1916, Boll. Lab d'Zool. gen. e agrar. d'scu. Sup. d'Agric., Portici, 11: 150-159 not *P. froggatti* Mayr years earlier.

**Chalcis aurea** Girault new species, Mem. Queensland Mus., 4: 321, 1915.

**Dimeromicrus breviventris** Girault new species, idem, 4: 277.

**Lincolnanna** new genus, family **Pteromalidae**

In my modernized table of genera, this species runs to *Apterosemoidella* but segment No. 2 of the abdomen occupies a bit over a fourth of the surface and distinctly exceeds the next three segments which are subequal and a bit over a half the length of No. 2 taken together. Furrows narrow, fine, curved lines. Clypeus bidentate, the teeth obtuse. Propodeum with a rather short neck, straight lateral carinae and a straight, rather narrow spiracular sulcus (nearly parallel with the lateral carina but not very close to it). There is a tooth-like projection centrally between the sulcus and the lateral margin. Petiole distinctly longer than wide. Sutures of the club faint, no nipple. Third ring-joint equal to the other two, larger than usual. Palpi 3- and 4-segmented. (A second tibial spur, very small and stout is indicated but doubted).

**Lincolnanna malpighii** nov. Genotype.

Small. Dark aeneus, the wings clear; legs (except the washed aeneus coxae) and the scape yellow. First funicle segment square, shorter than the pedicel, the others slightly smaller in succession. Scaly reticulate. Palpi dark except the pale distal joint (at least in outer pair), all joints of the outer longer than wide, No. 4 longest, No. 3 shortest and a half longer than wide. Middle femora with a stout, dark bristle near apex ventro-laterad.

Postmarginal vein elongate, subequal to the marginal, nearly twice longer than the long, slender stigmal, the latter slightly curved. Venation yellow, the stigmal knob black. Discal ciliation extending to the base of the marginal vein, nearly the cephalic half of its basal margin deeply bayed; a short, oblique line of larger cilia extends from the base of the bend of the submarginal vein (the basal nerve); and a loose pair of lines of still larger cilia (and more slender) extends under and along the marginal vein and amongst the other cilia of the regular discal ciliation.

Later, the wing was examined again in reference to the basal nerve just coming into notice; it is ciliated by 4-5 minute cilia (yet these are larger than the cilia of the main ciliation); and the vein is remote from both the main ciliation and the cubital nerve.

A female taken at Gympie, Queensland. Named for Abraham Lincoln.

### **Australochalcis** new genus, family Chalcididae

From *Chalcis*. Hind tibiae short, swollen distad, attaining only to the first femoral tooth. Scutellum flat, unarmed at apex. *Male*.

#### **Australochalcis humilicrus** nov. Genotype.

Black, the wings hyaline, their veins black. Red: Hind coxa, hind femur. Golden: Tegulae, first and second knees and the tarsi. There is also a small gold oval its own length from base, upon the hind tibia. This, of course, dorsad. Second segment of the abdomen equal to half of the surface. Hind femur with nine unequal teeth, all small. Funicle segments square, exceeding the pedicel.

More details are reserved for the Monograph noted. (MSS. now in Queensland Museum.)

A male taken at Chinchilla, Queensland, Nov., 1929. A. P. Dodd.

In accordance with the best possible practice, I have changed the name of the fourth genotype above because its first name was abominably long, having eight syllables. Nomenclature needs every possible assistance to simplify it, more especially in the needed provision of up-to-date lists of generic names.

---

### **German for the Scientist**

The author of this dictionary, through his association with students who were acquiring a reading knowledge of German, and with research workers who were attempting to put such knowledge to practical use, has realized that modern scientific research presents complicated interdepartmental problems. Hence any scientist needs a dictionary covering not only his own special field but many related fields as well. Dr. De Vries has attempted to prepare such a German-English science dictionary. In compiling it, he had the able assistance of many outstanding men of the science faculty of the Iowa State College. The result is "the first dictionary of its kind." It appears to be well suited to its purpose, and should be a boon to the graduate student and the researcher alike. There are 48,000 entries.

L. H. S.

**German-English Science Dictionary for Students in the Agricultural, Biological and Physical Sciences**, by Louis De Vries. x+473 pp. New York, The McGraw-Hill Book Co., 1939. \$3.00.

---

### **Science Down the Ages**

"Thought about the nature of the external world begins with magic, develops into religion, next reaches the level of philosophical speculation, and finally attains the scientific method." This passage from the early part of the book sets forth concisely the general plan of this history of science. From earliest times down to the present the thread of the development of science is traced. It is remarkable how much material has been packed into the short space of this essay, and it is gratifying to find that the style is delightfully readable. Student and layman alike will enjoy this account of the development of science and the methods of science.

L. H. S.

**The March of Mind**, by F. Sherwood Taylor. xiv+320 pp. New York, The Macmillan Co., 1939. \$3.00.

# THE NATURE OF THE EVOLUTION OF FUNDAMENTAL POTENTIALITIES IN THE PLANT KINGDOM<sup>1</sup>

JOHN H. SCHAFFNER

When one studies the plant kingdom in all of its more important aspects, he becomes aware of the fact that he is dealing with a remarkably consistent system, extending from very simple units on the lowest level to aggregates of exceedingly complex units on the highest level. The most remarkable facts in evidence are that the fundamental potentialities are added step by step as one follows up the ascending scale of complexity, that when once added these fundamental potentialities are not lost but are carried up to the highest levels of the plant series, and that therefore the plants of any general stage or subkingdom all possess a complement of similar fundamental potentialities. The plants of any subkingdom contain the complete complement of fundamental potentialities acquired in the forward evolution of the whole series to the given level.

From a practical and theoretical survey of the plant kingdom it becomes clearly evident that we can recognize ten progressive stages or subkingdoms. These stages are quite distinct and easily delimited from each other. Seven of them are represented by living forms and three are either theoretical or represented only by fossils. There are seven subkingdoms of living plants, no more and no less. One hundred general potentialities, represented by important structures or activities, have been segregated and listed below for the entire plant series. They are the potentialities which are most in evidence from the general viewpoint. Others could be listed, but they would not necessarily assist in making clearer the fundamental facts and principles involved.

The mechanisms in which these fundamental potentialities are contained are in the protoplast, but are not to be confused with genosomes having the potentialities for the genes of Mendelian heredity. In most cases the mechanisms may be conceived of as being complex systems of autogens scattered throughout the entire protoplast or a large part of it. Where in the protoplast, for example, is the mechanism causing the

---

<sup>1</sup>Papers from the Department of Botany, The Ohio State University, No. 411.

process of respiration? What is the nature of the protoplasmic pattern which determines the character and sequence of the twelve fundamental stages in the typical antithetic alternation of generations life cycle characteristic of all higher plants from the liverworts on up? What kind of a grouping of genosomes would determine that in the Bryophytes and Homosporous Pteridophytes the sexual state is always normally determined in the gametophyte, the sporophyte being a neutral generation, while when one passes up to the middle level of the Pteridophytes he finds that the sexual state is always determined in some stage of the sporophyte ontogeny throughout all the phyletic lines up to the highest seed plants? For such questions our present-day genetics has no answers. In fact, our present-day genetics is but a superficial discipline. These fundamental processes and characteristics are a part of the universal heredity of the plant much more important in the study of the general evolution and taxonomy of plants than all the superficial Mendelian genes, so far discovered, combined. For the present we may then simply assume that the protoplasmic mechanisms responsible for the fundamental potentialities are complex patterns of autosomes pervading in most cases at least the entire protoplast, although some may be confined to the nucleus only.

The ten subkingdoms are given below in connection with the one hundred fundamental potentialities. The fact of a definite, progressive, accumulative process in the evolution of the plant kingdom was presented in a general but incomplete way in two earlier papers. See "Principles of Plant Taxonomy, X" (Ohio Jour. Sci. 31: 77-96, 1931) and "Phylogenetic Taxonomy of Plants" (Quart. Rev. Biol. 9: 129-160, 1934).

ONE HUNDRED PROGRESSIVELY ACCUMULATED FUNDAMENTAL  
POTENTIALITIES EVOLVED IN THE PLANT SERIES,  
ARCHEOPHYTA TO ANGIOSPERMAE

In the progressive evolution of the plant kingdom, the fundamental potentialities acquired or changed to a more advanced condition are apparently never lost and very rarely inhibited in any group of organisms.

I. ARCHEOPHYTA. Biont stage; theoretical. The first five potentialities listed below are attributes of all plant and animal organisms.

1. With the genesis of living things or bionts there came into existence autogens possessing the power of assimilation or self-perpetuation. These autogens may be conceived of as definite patterns or

systems of molecules forming colloidal particles and having the power to duplicate themselves in their own field from the surrounding atoms, ions, and molecules.

2. The potentiality of self-division of the autogens with the two daughter particles retaining all the potentialities of the mother autogen.

3. The power of mutation, through which from time to time an individual autogen is changed to a new pattern with new potentialities.

4. Autogens of two or more kinds with the power of correlative interaction and a number of these ultimate living units held together in a unitary reaction field.

5. Nutrition, holotrophic but without chlorophyll. This condition was soon advanced to the chloro-holophytic condition and from either level there arose parasitic and saprophytic bionts and organisms, and in the animal series eating organisms.

II. PROTOPHYTA. Organisms with protoplasts. Beginning of the problem of cell organization and evolution of multicellular, complicated living mechanisms.

6. The simplest unicellular condition consisting of a definitely organized reaction system or protoplast. Practically all organisms up to the highest plants and animals exist as separate cells in one or more stages of their life cycle. The cells in the first evolutionary stage have either no definitely organized nucleus or a nucleus without either nuclear membrane or definite chromosomes and without a typical karyokinesis.

7. The potentialities for the simpler physiological processes of the cell, as absorption, mobility of the protoplasm, irritability, etc.

8. Respiration, which is a fundamentally important process taking place in the active cells of all plants and animals.

9. Division of the cell as a whole, with perpetuation of like structures and potentialities in the daughter cells, alternating with resting periods.

10. Development of a cell wall, with cellulose or other chemical compounds.

11. Development of alternate phases of walled cells and naked cells in the life cycle, rarely lost in any plants except in a few of the *Thallophyta*.

12. The evolution of a more complex system of the protoplasm with highly organized nucleus, with nuclear membrane, chromosomes, nucleolus, etc.

13. Development of a definite chloroplast with chlorophyll.

14. With the potentiality for chlorophyll production, came also the process of photosynthesis with the usual formation of sugar, starch, etc. This process and the production of chlorophyll are sometimes partly or completely lost by the evolution of inhibitory factors.

15. With the evolution of a more perfectly organized nucleus and chromosomes, the typical karyokinesis and resting stage of the higher plants and animals was initiated.

16. Definite organization of the chromosomes and their equational division.

17. A special system for the separation of the daughter chromosomes, including spindle fibers, centrosomes, a definite polar organization, and polar radiations at each karyokinesis.

18. Evolution of a flagellate or ciliate motor system, present in at least one phase of the life cycle, in the main line of the plant series and apparently never lost until the stage of the more advanced seed plants. The ciliate condition was developed in some series at a very low evolutionary level as in bacteria, and on the other hand, there is no evidence apparently that it was ever developed in such lines as diatoms, conjugates and red algae.

### III. NEMATOPHITA. Beginning of plants with sexuality.

19. Potentiality of sexuality with appearance of primary sexual states giving the property of attraction and fusion between isogamous gametes, the cells from time to time being in any of the three states—female, male, neuter.

20. The reduction division phase with synapsis of chromosomes. The sequences of fertilization, reduction, and the individual give rise to various types of life cycles.

21. Mendelian heredity as a result of fertilization and meiosis and exhibition of dominance and recessiveness in the diploid phase.

22. Multicellular condition, at first colonial, and with a restriction of separation of cells; in the main series developing a linear aggregate. In the highest plants the filament disappears or may be said to be restricted to the first two cells.

23. Attainment of heterogamy, through earlier determination in the cells of the sexual state.

24. Normal, higher type of heterogeny with extremely dimorphic gametes.

25. Correlative interaction of cells in the multicellular organism.

26. Differentiation system depending on physiological gradients in the multicellular body and a complexity of major and minor hereditary potentialities, not all of which are expressed at a given time or in a given cell.

27. Establishment of definite vegetative and reproductive phases in the process of differentiation, following a regular sequence in the usual ontogenetic cycle of the multicellular, differentiated plant body.

28. Development of base and apex of the filament and in the higher forms a base and apex in the growth of the solid aggregate individual.

29. Evolution of definite spermaries and ovaries and retention of the egg in the ovary.

30. Secondary sexual states in at least some of the body cells of the gametophyte causing secondary sexual dimorphism, through influencing hereditary expression, but not producing attractive properties as the primary states do in the gametes.

### IV. PROTO-BRYOPHYTA. The great transition hiatus leading to the Metathallophyta. There are no known living or fossil plants which represent this evolutionary level.

31. Progression from a linear aggregate to mature solid aggregate, the filamentous condition being confined to the juvenile phase of the

gametophyte. The solid buds produce a dorsiventral or bilateral gametophyte in the main series which in some lines advance more or less to a radial symmetry again.

32. Evolution of an epidermis and distinct internal tissues in the gametophyte or sporophyte or in both.

33. Evolution of rhizoids on the gametophyte. The rhizoids disappear in the higher plants through the great reduction of the gametophyte.

34. Typical antithetic alternation of generations life cycle established with the twelve antithetic stages.

35. Gametangia organized into definite types of archegonia and antheridia, which undergo progressive reduction in the higher groups of plants.

#### V. BRYOPHYTA. The lower homosporous Meta-thallophyta.

36. Completely parasitic, enclosed, one-phased sporophyte.

37. Radially symmetrical condition of the sporophyte.

38. Two-phased sporophyte, the juvenile enclosed and the mature exposed condition.

39. Development of the ability for dehiscence of the sporangium. This is never lost in the main series except in the megasporangium of seed plants.

40. General fundamental potentiality complex through which the sporophyte develops four general regions or systems—(1) an absorption system, (2) a supporting and conducting system, (3) a photosynthetic system, and (4) a spore-reproductive system.

41. Transpiration established in the sporophyte, with stomata. This system is very rarely lost.

42. Potentiality for a very definite type of stomata, the general type continuing to the highest plants.

43. Development of lateral expansions or outgrowths in some of the highest mosses, as the hypophyses of *Splachnums*.

44. Evolution of a central strand in the sporophyte, shown in the higher plants as the embryonic *plerome*, as distinguished from the *periblem* or cortical tissue.

45. First stage, in the evolution, of the shifting of spore reproduction from the central axis to the periphery, by the development of a central *columella* in the sporangium of the higher Bryophytes.

#### VI. PROTO-PTERIDOPHYTA. Large transition hiatus leading to the homosporous vascular plants.

46. Two-phased sporophyte with parasitic and completely independent phases, the enclosed and exposed conditions still present in the parasitic phase, as in the Bryophytes.

47. Sinking of the archegonium venter into the tissues of the gametophyte. The horned liverworts of the Bryophyta also have sunken archegonium venters.

48. Potentiality for long-continued growth of the sporophyte.

49. Complete evolution of indeterminate growth of the sporophyte, the reproduction process not followed by immediate death. In the



higher plants this potentiality may be inhibited by the introduction of the annual habit.

50. Negative geotropism of the stem bud.

VII. PTERIDOPHYTA HOMOSPORAЕ. Completely evolved vascular plants with a two phased sporophyte and an indeterminate axis.

51. The normal vascular system, appearing in all the lines of higher plants, in the main evolutionary line with pith on the inside and cortex on the outside.

52. Highly evolved cambium system with secondary growth in thickness, in the main series. This potentiality is, however, reduced or lost in various phyletic lines but not in the main ones.

53. Potentiality for the production of typical leaves with a vascular supply.

54. Fundamental potentiality for the spiral development of the leaves in the sporophyte. This spiral growth reaction is present with various modifications in all living vascular plants, and apparently in some fossil Proto-Pteridophyta.

55. The complete centrifugal shifting of the reproductive process from the stem tip and central axis to the leaves.

56. Roots, originating at first as lateral organs and later as basal organs of the embryo.

57. Geotropism of roots.

58. Decided dorsiventrality of the leaves usually with phototropism.

59. Branching potentiality evolved which is normally monopodial in all living lines except in the Lepidophyta in which it is dichotomous and was apparently introduced in a very early Proto-Pteridophyte stage.

60. Dimorphism between sporophylls and foliage leaves attained on the higher levels.

VIII. PTERIDOPHYTA HETEROSPORAЕ. Attainment of the level in which sex determination takes place in the sporophyte.

61. Shifting of time of sex determination from the gametophyte to the sporophyte.

62. In consequence of shifting of time of sex determination both secondary male and female states developed in some part of the sporophyte, on the lowest level in the same sorus of a leaf.

63. In consequence of secondary sexual states in the sporophyte, dimorphic sporangia, sporocytes, and spores produced, microspores and megaspores.

64. Unisexual gametophytes, having their sex completely established in the spore before germination. The establishment of secondary sexual states before the time of the reduction division determines that there is no segregation of sex through the separation of the synaptic chromosomes but all the spores and the subsequent gametophytes coming from one sporocyte continue the sexual state previously established in the sporangium and sporocyte. Sex-reversal in heterosporous gametophytes is very rare.

65. Decided reduction in size of gametophytes, namely more prompt determination of cell lineage.

66. Very extreme dimorphism of the male and female gametophytes.

67. Earlier sex determination in the ontogeny, each sorus having but one secondary state developed.

68. Advance in time of sex determination to the inception of the sporophyll, resulting in dimorphism of sporophylls, megasporophylls and microsporophylls.

69. Decided reduction of the antheridium to a single unit in the male gametophyte.

70. Complete or nearly complete inhibition of chlorophyll development in the gametophytes which are dependent on the parent sporophyte through the food stored in the spores.

IX. GYMNOSPERMAE. Attainment of the seed habit, with parasitic gametophytes.

71. Retention of megaspores and microspores, with germination in the sporangia.

72. In consequence of spore retention, parasitic gametophytes.

73. Pollination process established.

74. Acquisition of a two-phased male gametophyte with development of the parasitic pollen tube in the ovule.

75. Ovules or megasporangia with integuments.

76. Resting stage of embryo intercalated between the parasitic and independent phases of the sporophyte, resulting in seed dormancy.

77. Abscission of fruit or seed.

78. Food storage, during development of the seed, in the embryo sporophyte or surrounding parasitic tissues or in both, which enables the embryo to become established as an independent plant in the process of sprouting.

79. Sprouting of the seed or renewal of growth activity in the sporophyte embryo, with complex reactions developed at this phase, not only an awakening from dormancy but various other activities, as the definite reaction to gravity, etc.

80. Increase in functional axillary bud development to a greater or less degree, giving rise, on the higher levels, to much branched systems, which may be simplified again in various higher series through a counter-evolutionary movement, as shortening the ontogeny to the annual condition, etc.

81. Determinate reproductive axis of the sporophyte, or flower potentiality, in all the higher series. The lowest fossil Gymnosperms are without flowers and a few living species still have indeterminate reproductive axes, while many of the Pteridophytes have flowers.

82. Extreme differentiation of tissues of carpel and stamen from leaf tissue, the carpels and other parts modified with them finally giving rise to the fruit.

83. Evolution of a standard type of embryo with radicle, plumule, and cotyledons.

84. Development of a peduncle below the flower, on the higher levels in various lines. This may be reduced again. Peduncles are also developed in some Pteridophytes.

85. Development of internodes in most of the higher series. These may be reduced again through new evolutionary movements. Some of

the lower groups, even of Homosporous Pteridophytes also have the internodal potentiality.

X. ANGIOSPERMAE. The extreme stage of complexity of fundamental potentialities, with closed carpels, stigmas and endosperm developing from a triploid or polyploid fusion nucleus.

86. Development of special complex types of xylem vessels in the vascular bundles.

87. Closing of the carpellate leaf, producing an ovulary.

88. Development of a stigma.

89. Potentiality for a very consistent type of microsporophyll, or stamen, normally with a filament and an anther with four microsporangia which are rarely reduced to two.

90. Very decided limitation of the growth of the gametophytes to an eight-celled female and a three-celled male condition, as the usual type in most groups.

91. In nearly all cases a three-celled egg-apparatus, which apparently represents a vestigial archegonium.

92. Development of the pollen tube through the stigma, style, open cavity of the ovulary, and the micropyle. This condition sometimes modified by the introduction of chalazogamy.

93. Evolution of nonciliated spermatozooids. This condition is also attained in the higher phylum of the Gymnosperms, the Strobilophyta.

94. Triple or multiple fusions within the female gametophyte resulting in a primary endosperm nucleus in addition to the diploid oospore.

95. Triploid or occasionally polyploid endosperm or xeniophyte.

96. Potentiality for a definite gradient in the bisporangiate flowers, causing male expression first, and followed by a sex-reversal to female expression. This is modified in many lines by the progression in the time of sex-determination to monociousness and dieciousness, but commonly with vestigial development of the opposite set of sporophylls.

97. Potentiality for the development of a perianth which is rarely completely lost through the progressive evolution of the determinateness of the flower. There is a slight development of the perianth in some groups of Pteridophytes and Gymnosperms.

98. Differentiation of the perianth into a distinct calyx and corolla, except in some of the lowest types and some of the advanced, reduced types of flowers.

99. Evolution of an inflorescence in all but the lowest types. This is occasionally reduced again to a solitary flower in some of the advanced lines.

100. Union of the carpels into a gynecium with a compound ovulary in all except the lowest members of the various phylogenetic series. The ovulary is usually plurilocular in the lower levels and unilocular in the higher levels.

One may wonder as to what is the fundamental cause of this remarkably consistent, progressive accumulation of fundamental modes of reaction. Whatever the cause, this accumu-

lative, irreversible series gives a definite picture of the primary evolutionary process. It shows that evolution in its fundamental aspects is an intrinsic and definitely kinetic process and that there is a principle of stability involved as well as a principle of change. It also shows that the plant kingdom as a whole is a direct contradiction of the old teleological hypotheses of evolution as contained in Buffon's direct response to environment, Lamarck's use and disuse, and Darwin's natural selection. It also is plainly a contradiction of some of the newer genetic hypotheses which attribute the primary cause of evolutionary action to the effect of various kinds of radiations on the cell, such as cosmic rays, violet rays, X-rays, etc. These universal physical agents have been active during the geological ages and must have hit every susceptible particle of protoplasm of all plants myriads of times, and if they were primary causal agents we should either have a plant kingdom of a single species or a haphazard, anarchistic taxonomic system; which is a direct contradiction of the actual evolution which has taken place.

When one has ascertained the fundamental potentialities for each subkingdom, one may proceed to catalog all the potentialities or characteristics contained in each phylum or class or other group in addition to the accumulation common to the entire subkingdom in which the phylum or class has its basis. This has not been attempted, but to illustrate the way the method can be used in determining the evolutionary level to which any species has attained a list of the total potentialities or characteristics possessed by the species may be made. Some of these potentialities may be simple Mendelian genes. The writer has attempted to catalog thirty-four species in this manner, a summary of which is presented in the chart given below. Eight of these summations are here presented to illustrate the progression of complexity from the lowest to the highest level.

No claim is made that these summations are complete, for a complete summation will require an enormous amount of study of each species. However, an attempt has been made to study the different species on the same general basis and thus the series of numbers for the eight examples given—16, 42, 68, 95, 122, 140, 170, 200—does clearly indicate each species' position in the taxonomic scale. A similar method can be used to determine the relative position of the genera or species in a group in relation to each other if they are to be arranged in the order of their evolutionary complexity as higher or lower types.

### **Nitrosococcus nitrosus Mig.**

This is an autotrophic bacterium belonging to the Coccaceae and represents the lowest type of organism. This autophyte was isolated from the soil of Quito, Ecuador, South America, by Winogradsky.

Phylum, Schizophyta; class, Schizomycetae; order, Bacteriales; family, Coccaceae.

I. The first ten of the one hundred enumerated potentialities of the general accumulative list.

II. The special potentialities accumulated in the species.

11. The specific type of autotrophic reaction deriving energy through oxidizing ammonia to nitrite and obtaining carbon from the atmospheric carbon dioxide.

12. The spherical or coccus shape, which is the simplest shape of a bit of colloidal protoplasm surrounded by a wall.

13. Specific size of the rather large cells, with a diameter of 1.4–1.7 microns.

14. Non-motile condition—no motile stage known. The absence of cilia represents the simplest, most primitive condition of the living cell.

15. Apparent absence of a zooglyca stage, always growing as free cells without special pigment formation. This represents the simplest cellular condition imaginable.

16. Potentiality for a special physiological condition—an obligate aerobe.

The first ten conditions are fundamental potentialities common to all higher organisms. In the higher, however, there is a definite nucleus with a more complex structure. *Nitrosococcus nitrosus* has apparently only six special characteristics, and even of these two appear quite generally in the life cycle of higher organisms, namely the spherical, free cell condition and the non-motile condition.

### **Sphaerella lacustris (Girod.) Wittr.**

This active unicellular alga is often abundant in rain water pools and often colors these a bright red because of the development of haematochrome in its cells.

Phylum, Gonidiophyta; class, Chlorococceae; order, Volvocales; family, Chlamydomonadaceae.

I. The first twenty-one of the one hundred general potentialities.

II. The accumulation of special potentialities in the species.

22. Potentiality giving motile and no-motile vegetative cells in the ontogeny.

23. Flagella developed in the motile stage or zoospores.

24. The definite biciliate condition of the zoospores and gametes.

25. Centrosomes present, the dynamic centers of the flagella, spindle poles, and polar radiations.

26. An eye spot in the active cells.

27. Spherical shape of the resting cells.

28. Oblong-ovoid shape of the gametes.

29. The resting zygote.
30. Cuticularized wall of the zygote.
31. Potentiality for the red coloring matter or haematochrome.
32. Pointed ciliate end of the zoospores with two minute openings in the cellulose wall.
33. Peculiar, loose cell wall of the zoospore with protoplasmic strands passing to the protoplast within.
34. Characteristic size of the cells of the species.
35. Characteristic size and shape of the bell-shaped chloroplast.
36. A pyrenoid in the chloroplast.
37. Long resting stage or dormancy under dry conditions without loss of vitality.
38. Gelatinous pectose in the cellulose wall.
39. Power of dissolving the cell wall at certain points.
40. Definite reaction to light.
41. Characteristic swarming of the gametes in the water.
42. Diploid number of chromosomes in the zygote, with the reduction division during its germination.

### ***Riccia fluitans* L.**

This species is a simple liverwort growing in the water or on wet banks.

Phylum, Bryophyta; class, Hepaticae; order, Marchantiales; family, Ricciaceae.

I. The first thirty-eight potentialities of the general series.

II. The special potentialities accumulated in *Riccia*.

39. Potentiality determining the slender thalloid form of the gametophyte.
40. Gametophyte conditioned to live in fresh water.
41. Dichotomous branching.
42. Adventive branches from ventral sides of the thallus in the floating form.
43. Several distinct tissue layers in the thallus.
44. Thallus with a median furrow.
45. Development of large air cavities.
46. Dorsal epidermis of thallus.
47. Small openings in the epidermis to the air chambers in the terrestrial form.
48. Ventral scales in a row.
49. Double row formed by rupturing of the ventral scales.
50. Characteristic form of the scales.
51. Rhizoids with a smooth inner surface.
52. Tuberculate rhizoids.
53. Violet color of the ventral scales and the margins of the thallus.
54. Hermaphroditic condition of gametophyte.
55. Characteristic antheridia.
56. Archegonia with stalk, venter, neck, and lid cells.
57. Special division of the egg mother cell to form the egg and ventral canal cell.

58. Spherical form of the egg.
59. Dissolving of the neck canal cells and the ventral canal cell.
60. Opening of the lid cells of the neck.
61. Antheridia and archegonia immersed singly in cavities of the dorsal surface, scattered in the thallus.
62. Prominent antheridial ostiole.
63. Biciliate spermatozoids which swim down the necks of the archegonia.
64. Spherical sporophyte in the venter.
65. Ventral protuberance of the thallus, produced by the growth of the sporophyte.
66. Complete transformation of the inside of the sporophyte into sporocytes and spores.
67. Characteristic, large spores with aerolate surface.
68. Disappearing of the epidermal wall of the sporophyte (sporangium) at the maturing of the spores.

### *Ophioglossum vulgatum* L.

The adder-tongue fern represents about the simplest condition of the living vascular plants, at least of those belonging to the Ptenophyta.

Phylum, Ptenophyta; class, Phyllopteridae; order, Ophioglossales; family, Ophioglossaceae.

- I. The first fifty-nine fundamental potentialities of the general series.
- II. Accumulation of potentialities in the *Ophioglossum* series.
  60. A short, nearly erect, slow-growing retreating rhizome.
  61. Character of the cortex of the rhizome.
  62. Distinctive type of vascular bundles with characteristic wood cells.
  63. Characteristic shape of foliage leaf.
  64. General size of leaf.
  65. Evolution of petiole.
  66. Characteristic type of bud on the rhizome.
  67. Potentiality for reticulate or arceolate venation.
  68. Several vascular bundles in base of leaf.
  69. Erect vernation of leaves.
  70. Distribution of stomata.
  71. Succulent texture of plant.
  72. Slender fleshy roots, occasionally with dichotomous branching.
  73. Specific structure of the roots.
  74. Sporophyll with distinct sporangiophore on upper side.
  75. Long stalk of sporangiophore.
  76. Characteristic round sporangia.
  77. Sporangia in two rows on sporangiophore.
  78. Characteristic dehiscence of bivalved sporangia.
  79. Characteristic shape and size of spores.
  80. Yellow color of spores.
  81. Germination of spores to form a small characteristic protonema.
  82. Potentiality for subterranean growth of gametophyte.
  83. Bean-shaped character of gametophyte.

84. Thick, fleshy texture of gametophyte.
85. Potentiality inhibiting the development of chlorophyll in gametophyte.
86. Mycorrhizal relation with a fungus, giving phagophytic nutrition.
87. Character of the rhizoids on gametophyte.
88. Hermaphroditic condition of gametophyte.
89. Short neck of archegonium.
90. Lid cells of archegonium.
91. Division of mother cell into the egg and ventral canal cell.
92. Neck canal cells and ventral canal cells dissolving.
93. Characteristic antheridia.
94. Large, spirally coiled, multiciliate spermatozoids.
95. Characteristic bryophyte type of embryo development, the inner of the first two cells of the embryo giving rise to the foot and the outer one to the first leaf, bud and root.

### **Marsilea quadrifolia L.**

The European *Marsilea* is commonly cultivated in greenhouses and botanic gardens and occasionally escapes into favorable habitats. It is the lowest type of the living, leptosporangiate heterosperous ferns.

Phylum, Ptenophyta; class, Hydropteridae; order, Marsileales; family, Marsileaceae.

- I. The first seventy fundamental potentialities of the general series, except No. 60.
- II. The accumulation of special potentialities in the *Marsilea* line.
  70. Highly evolved creeping, rapidly growing rhizome.
  71. Potentially fitting the plant for a moist ground of aquatic habitat.
  72. Potentiality for internodes between the leaf nodes.
  73. Characteristic vascular system with absence of secondary thickening.
  74. Characteristic cortex of the rhizome.
  75. Sporadic monopodial branching of the rhizome.
  76. Characteristic type of roots.
  77. Structure of the roots.
  78. Reaction to gravity and substratum of the rhizome.
  79. Foliage leaf with four leaflets.
  80. Long slender petiole.
  81. Structure of the petiole.
  82. Shape and size of the leaflets.
  83. Structure and venation of leaflet.
  84. Smooth upper surface of leaflet and slightly hairy lower surface.
  85. Distribution of stomata.
  86. Reaction to darkness and light, the leaflets folding up like a fan and also nutating with the sun at least in *M. vestita*.
  87. Special type of sporophyll, having a special primary dichotomy, the one branch being vegetative, the other reproductive.



88. Usually a single dichotomy of the reproductive branch of the sporophyll.

89. Special length of petiolule bearing the sporocarps.

90. Closing up of the reproductive leaflet and complete fusion of its two valves to form the sporocarp.

91. Yellowish-brown hairs on the petiolules of the sporocarps.

92. Characteristic shape and size of sporocarp, with two teeth at its base.

93. Smooth surface of sporocarp.

94. Hard texture of the mature sporocarp.

95. Internal organization of the sporocarp into eight or nine sori or compartments in each of the two valves.

96. Potentiality for the transformation of the internal tissues of the sporocarp into a gelatinous mass which comes out as a gelatinous cord, bearing the two types of sporangia, when the sporocarp breaks open by two valves in the water.

97. Potentiality which determines the comparative number and distribution of megasporangia and microsporangia in each sorus.

98. Characteristic time of sex-determination in the incipient sporangia.

99. Shape and size of the megasporangium.

100. Cellular structure and shape of the megasporangium.

101. Short thick stalk of the megasporangium.

102. Character of the single surviving megaspore as to shape, size, and surface.

103. Potentiality which causes the destruction of several megaspores during the growth of the surviving megaspore.

104. Character of the abundant supply of starch grains in the megaspore.

105. Spherical shape and small size of the microsporangium.

106. Long slender stalk of the microsporangium.

107. Cellular structure of microsporangium.

108. Abundant number of microspores in a microsporangium.

109. Character of the microspores as to shape, size, and surface.

110. Characteristic development of the female gametophyte in one end of the megaspore.

111. Characteristic opening of the end of the megaspore and the protrusion of the neck of the archegonium.

112. Simple character of the cellular structure of the female thallus.

113. Lack of chlorophyll in the male gametophyte and young female gametophyte.

114. Character of the archegonium with very short neck.

115. Abundant funnel-like mass of gelatinous material coming from the neck of the archegonium into which the spermatozooids swim.

116. Characteristic small male gametophyte developed in the microspore.

117. Cellular structure of the male gametophyte.

118. Very small and reduced antheridium, producing only a few spermatozooids.

119. Bulging out and breaking open of the microspore wall next to the tip of the antheridium through which the spermatozooids escape.

120. Characteristic, large, spirally coiled, multiciliate spermatozoid.
121. Characteristic embryogeny.
122. General character of the young sporophyte with one cotyledon.

***Araucaria araucana* (Molina) K. Koch.**

The Monkey-puzzle-tree represents a primitive conifer type, as indicated by its broad, spirally arranged leaves, its intermittent, rhythmically developed zones of main branches with very coarse ultimate branchlets, and its very primitive type of flowers.

Phylum, Strobilophyta; class, Coniferae; order, Araucariales; family, Araucariaceae.

- I. The first eighty-three fundamental potentialities of the general accumulative series.
- II. The special potentialities of the *Araucaria* series.
  84. Sperms without cilia.
  85. Ovules developing without a pollen-chamber.
  86. Ovules imbedded in the lower part of the carpel.
  87. One ovule for each carpel.
  88. Peculiar growth of pollen tube through the carpel tissue.
  89. Greater growth of pollen tube as compared with Cycadophyta.
  90. Flower production shifted beyond the primary stem axis.
  91. Special type of spiral systems in the flowers.
  92. Flowers monosporangiate.
  93. Diecious condition.
  94. Characteristic staminate cone.
  95. Leaf-like stamens.
  96. Stamens with numerous pollen-sacs.
  97. Character of wall of the slender pollen-sac.
  98. Characteristic ovoid carpellate cone.
  99. Shape and size of carpel.
  100. Texture of carpel.
  101. Special small ligule on the carpel.
  102. Character of ripe carpellate fruit.
  103. Characteristic size and shape of pollen-grain.
  104. Male gametophyte with numerous vegetative nuclei.
  105. Characteristic female gametophyte, originating in a large number of free cells.
  106. A number of archegonia in each female gametophyte.
  107. Characteristic archegonium with twelve neck cells.
  108. Egg and short-lived ventral canal cell.
  109. Characteristic embryogeny.
  110. Embryo with two cotyledons.
  111. Vascular supply of each cotyledon.
  112. Seed dry and large.
  113. Character of the testa of the seed.
  114. Elongated shape of mature seed.
  115. Characteristic mode of sprouting.
  116. Thickening of the hypocotyl.
  117. Type of the spiral arrangement of the leaves.

118. Rhythmical development of zones of branches of the main stem.
119. Meager development of axillary buds.
120. Very robust ultimate twigs.
121. Large broad leaves.
122. Characteristic parallel venation with dichotomy.
123. Smaller leaves in resting zones.
124. Firm thick texture of leaves.
125. Distinctive character of stomata.
126. Abscission of ultimate twigs.
127. Resin passages in the leaves.
128. Highly efficient cambium, producing a large wood cylinder.
129. Wood with uniform tracheids.
130. Tracheids with multiseriate bordered pits, and with spiral thickenings in the primary wood.
131. Characteristic medullary rays one cell in width.
132. Resin produced in the medullary rays and in passages in the roots and bark.
133. Double leaf-traces persistent in the secondary wood.
134. Rather large pith in contrast with other conifer groups.
135. Characteristic outer bark.
136. Cork cambium.
137. Characteristic structure of inner bark.
138. General characteristics of the wood, as strength, fracture, and durability.
139. Development of a tap-root.
140. Branching system of roots.

***Magnolia acuminata* L. Cucumber Magnolia.**

The *Magnolia* is one of the most primitive types of Dicotyls, although it is probably considerably advanced over the form which must have represented the original ancestral simple tree.

Phylum, Anthophyta; class, Dicotylae; order, Ranales; family, Magnoliaceae.

- I. The ninety-eight fundamental potentialities of the general accumulative series.
- II. The special potentialities accumulated in the Cucumber Magnolia.
  99. Highly evolved woody stem system.
  100. Resting vegetative bud.
  101. Netted-veined character of leaves.
  102. Pinnate venation from a prominent midrib.
  103. Dichotomy of the main lateral veins.
  104. Characteristic branching habit.
  105. Development of a cork cambium.
  106. Characteristic type of outer bark.
  107. Characteristic inner bark.
  108. Rather large pith.
  109. Soft texture of pith.
  110. Characteristic root system.
  111. Branching of roots.

112. Development of root hairs.
113. Reduction of spiralization to a 2-3-5-1 leaf spiral on the vegetative stem.
114. Characteristic length of internodes.
115. Large stipules.
116. Connate condition of stipules.
117. Stipules extending completely around the stem.
118. Silky pubescence on the stipules.
119. Abscission of stipules.
120. Conduplicate folding of leaf in the bud.
121. Characteristic shape of leaf.
122. Characteristic size of leaf.
123. Entire margin of leaf blade.
124. Leaf blade with minute transparent dots.
125. Pubescence on lower side of leaf.
126. Petiole of leaf.
127. Abscission of leaf.
128. Numerous bundle-scars in leaf scar.
129. Characteristic stipular rings on twigs.
130. Bitter aromatic bark.
131. Characteristic, nearly glabrous peduncle of flower.
132. Three-parted perianth.
133. Differentiated calyx and corolla.
134. Double cycle of petals.
135. Characteristic shape and size of sepals.
136. Texture of sepals.
137. Characteristic shape and size of petals.
138. Texture of petals.
139. Greenish-yellow color of petals.
140. Glaucous condition of perianth and gynecium.
141. Deciduous perianth segments.
142. Characteristic shape and size of carpels.
143. Carpels cohering together.
144. Characteristic spiral condition of carpels in gynecium.
145. Shape and size of stamens.
146. Characteristic spiral condition of stamens in andrecium.
147. Color of stamens.
148. Shape of microsporangia.
149. Characteristic shape and size of pollen.
150. Color of pollen-grains.
151. Fragrance of the flowers.
152. Carpels forming follicles.
153. Each carpel with two ovules.
154. Ovules anatropous.
155. Characteristic wall of follicles.
156. Rose color of mature cylindric cone of carpels.
157. Dehiscence of follicles.
158. Fleshy outer seed coat.
159. Red color of seed coat.
160. Bony inner seed coat.

161. Thread-like slender funiculus of seed.
162. Persistence of follicles on the receptacle of the fruit.
163. Fleshy endosperm.
164. Characteristic embryogeny.
165. Very small embryo.
166. Characteristic sprouting of embryo.
167. Wood with distinct heartwood and sapwood.
168. Characteristic medullary rays.
169. Wood diffuse porous.
170. Soft, light character of the wood.

***Taraxacum officinale* Weber. (*Leontodon taraxacum* L.). Dandelion.**

The dandelion is one of the most highly evolved plants and represents the main culmination type in the plant kingdom.

Phylum, Anthophyta; class, Dicotylae; order, Compositales; family, Cichoriaceae.

I. The one hundred general fundamental potentialities.

II. The special potentialities accumulated in the Dandelion series.

101. The change from the more primitive type of stem to the low herbaceous type.

102. The evolution of a typical perennial rosette.

103. Netted-veined leaves.

104. Prominent midvein and weak lateral veins of the pinnately veined leaves.

105. Characteristic angiospermous embryogeny.

106. Two cotyledons.

107. Primitive spiral to cyclic condition of flower.

108. Tetracyclic condition of flower.

109. Syncarpous condition.

110. Advanced determinate condition of the floral axis resulting in epigyny.

111. Change from plurilocular to unilocular ovulary.

112. Single ovule and seed in ovulary.

113. Anatropous ovule from original orthotropous type.

114. Shifting of flowers away from the primary axis to the axillary position.

115. Disk or head evolved, an extremely determinate inflorescence axis.

116. Double condition of involucre bracts around the disk.

117. Characteristic size and shape of the outer bracts.

118. Characteristic size and shape of the inner bracts.

119. Characteristic texture and structure of the bracts.

120. Reflexing of involucre bracts at maturity; two periods, the outer first.

121. Suppression of the leaf bracts subtending the individual flowers.

122. Characteristic white epidermal layer on top of the disk.

123. Very small flowers.

124. Reduction of stigmas to two.

125. Minutely papillose surface of stigmas.

126. Coiling of stigmas.
127. Sympetalous condition of corolla, the original free petal condition still represented by the vestigial corolla lobes.
128. Tubular shape of corolla.
129. Texture of corolla.
130. Zygomorphic corolla with strap-shaped condition.
131. Centripetal split of the inner sides of the corollas, giving radial symmetry to the head.
132. Yellow color of corolla.
133. Outer ligulate corollas with broad purplish band beneath, the inner ones without such band.
134. Characteristic stamens with delicate filaments.
135. Sagittate anthers.
136. Union of stamen filaments with corolla.
137. Union of anthers, or synantherous condition.
138. Characteristic pollen grain.
139. Color of pollen.
140. Minute pedicel of flower.
141. Pappus development, replacing calyx.
142. Characteristic simple nature of individual pappus bristles.
143. Nectar gland in flower.
144. Characteristic nectar excreted.
145. Complex leaf reaction during the ontogeny, giving a succession of leaf types.
146. Juvenile leaf shape.
147. Lobed leaf type of the older plant.
148. General size of leaf.
149. Characteristic texture of leaf.
150. Characteristic leaf margin.
151. Soft narrow teeth on the lobes.
152. Flat, sheathing leaf base.
153. Lactiferous vessels.
154. Secretion of latex with bitter principle.
155. Margined petiole.
156. Hollow peduncle or scape.
157. Characteristic texture of the peduncle.
158. Property for great elongation of the peduncle in suitable environment to three feet or more.
159. Hollow petiole and midrib.
160. Delicate hairs on the leaf blade.
161. Long silky hairs at base of petiole.
162. Characteristic shape of roots.
163. Characteristic texture of roots.
164. Branching of roots.
165. Special longitudinal segmentation of the old main root.
166. Special reproductive ability of roots, any little piece being able to develop a new plant.
167. Root hairs on root tips.
168. Fruit an achene.
169. Development of parachute neck or strand at top of achene.

170. Shape of mature achene.
171. Characteristic texture of achene wall.
172. Prominent conical beak on the achene.
173. Special ribs and grooves on the achene.
174. Prominent projections, especially at the upper part of the achene.
175. Color of achene.
176. Hygroscopic closing and opening of pappus bristles in wet and dry conditions.
177. Shape and size of stem.
178. Slow growth of stem producing the leaf rosette.
179. Characteristic cortical region of stem.
180. Definite physiological gradient in the growing bud giving five kinds of stem development in succession: 1, the rosette stem; the peduncle; 3, the disk; 4, the pedicel; 5, the cortical stem tube from which the ovary is developed.
181. Special vascular system in the rosette stem.
182. Arrangement of vascular bundles in the peduncle.
183. Vascular supply in the expanded disk.
184. Nature of the vascular system in the pedicel.
185. Characteristic spiral phyllotaxy in the rosette.
186. Spiral arrangement of flowers on the disk.
187. Closing of flower heads in the dark and in low temperature.
188. Potentiality interfering with complete sexualization of chromosomes, producing imperfect synapsis at reduction.
189. Irregularity of reduction in the anther.
190. Regularity of partial synapsis in the ovule, giving rise to diploid megaspores.
191. Characteristic shape and size of the one functional megaspore, with dissolution of the three vestigial megaspores.
192. Characteristic diploid female gametophyte arising from the diploid megaspore.
193. Characteristic egg apparatus with diploid egg.
194. Parthenogenetic development of the diploid egg.
195. Interference with Mendelian hereditary transmission because of diploid parthenogenesis.
196. General nature of endosperm development.
197. Characteristic mature embryo sporophyte.
198. Characteristic sprouting of the seed.
199. The character of the seedling cotyledons.
200. Potentiality to produce anthocyanin, especially in the young plant.

SUMMARY OF ACCUMULATION OF POTENTIALITIES IN THIRTY-FOUR  
SPECIES OF PLANTS

NAME OF PLANT	GENERAL POTENTIALITIES	SPECIAL POTENTIALITIES	TOTAL
<i>Nitrosococcus nitrosus</i> Mig.....	10	6	16
<i>Rivularia echinulata</i> (Smith) B. & F. ....	11	22	33
<i>Scenadesmus quadricauda</i> (Turp.) Breb..	17	11	28
<i>Sphaerella lacustris</i> (Girod.) Witttr.....	21	21	42
<i>Spirogyra reflexa</i> Trans.....	21	18	39
<i>Puccinia graminis</i> Pers.....	26	29	55
<i>Dictyophora phalloides</i> Desv.....	26	32	58
<i>Chara crassicaulis</i> Schleich.....	30	32	62
<i>Polysiphonia variegata</i> (C. Ag.) J. Ag....	29	35	64
<i>Riccia fluitans</i> L.....	38	30	68
<i>Frullania asa-grayana</i> Mont.....	39	41	80
<i>Archidium ohioense</i> Schimp.....	40	35	75
<i>Polytrichum commune</i> L.....	45	40	85
<i>Ophioglossum vulgatum</i> L.....	59	36	95
<i>Onoclea sensibilis</i> L.....	60	45	105
<i>Equisetum arvense</i> L.....	60	51	111
<i>Marsilea quadrifolia</i> L.....	69	53	122
<i>Selaginella krussiana</i> (Kunze) A. Br....	70	55	125
<i>Cycas revoluta</i> Thunb.....	84	59	143
<i>Zamia integrifolia</i> Ait.....	84	65	149
<i>Araucaria araucana</i> (Mol.) K. Koch....	83	57	140
<i>Taxodium distichum</i> (L.) Rich.....	84	69	153
<i>Pinus radiata</i> D. Don.....	83	88	171
<i>Ephedra viridis</i> Cov.....	85	95	180
<i>Echinodorus cordifolius</i> (L.) Gris.....	99	71	170
<i>Vallisneria spiralis</i> L.....	100	80	180
<i>Zea mays</i> L.....	100	85	185
<i>Iris germanica</i> L.....	100	89	189
<i>Tipularia unifolia</i> (Muhl.) B. S. P.....	100	92	192
<i>Magnolia acuminata</i> L.....	98	72	170
<i>Viola papilionacea</i> Pursh.....	99	84	183
<i>Salvia pulcheri</i> Torr.....	100	86	186
<i>Salix interior</i> Row.....	100	85	185
<i>Taraxacum officinale</i> Weber.....	100	100	200



## BOOK REVIEWS

### Modern Genetics

The development of modern genetics has brought increasingly close relationships between the facts of heredity and the fields of evolution, embryology, cellular biochemistry and cytology. The author of the present volume, believing that these relationships rather than the mere mechanics of Mendelian segregation should be the theme of genetics text books, has written a text with this in mind. Mendelian inheritance itself is given short shrift in a few pages: perhaps too short for the elementary student. Then follow very fine discussions of the chromosome cycle and its modifications, the behavior of individual chromosomes, the linear differentiation of chromosomes, including an excellent account of crossing over and chiasmata. The foregoing topics comprise Part I. Part II considers the facts of embryology and their relations with genes and gene interactions. Part III is devoted to genetics and evolution, with up-to-date discussions of species formation, selection, cytoplasmic inheritance and related topics. Part IV takes up genetics and human affairs, including plant and animal breeding and a modern discussion of human inheritance. Part V is given over to a discussion of the nature of the gene. Here are discussed such topics as cellular biochemistry, effects of radiation, position effects, rate and causes of mutation, and estimates as to the size of the gene. The book is well illustrated and the references are frequent and modern. Teachers of genetics will find the book invaluable, but it appears to be somewhat in advance of the usual elementary genetics class. Perhaps beginning courses in genetics should be geared to this higher rate of progress. The book can be unreservedly recommended for advanced classes. A short appendix gives a concise account of methods of using *Drosophila* in class work. A surprising number of grammatical errors mars the otherwise pleasurable reading of the volume.—*L. H. S.*

**An Introduction to Modern Genetics**, by C. H. Waddington. 441 pp. New York, the Macmillan Co., 1939. \$4.00.

---

### A New Genetics Textbook

The new genetics text, "An Introduction to Genetics," by Beadle and Sturtevant, is unique in several respects. Of the twenty-three chapters, thirteen are devoted to a discussion of the ordinary behavior of chromosomes and hereditary factors. Five chapters are given over to a discussion of the various types of chromosomal aberrations and polyploidy. A separate chapter is devoted to each of the following topics: position effects, species differences, extra-chromosomal inheritance and material influences, genes and phenotypes, and a historical outline of genetics.

The order of presentation is most unusual. The first two chapters deal with sex chromosomes and sex-linked factors. Mendel and autosomal inheritance not being mentioned until the third chapter. Chapters on inversions and incomplete chromosomes precede the chapters on lethals and multiple alleles. Special emphasis is placed upon both normal and abnormal chromosomal behavior, with abundant references to *Drosophila* and maize. A full page plate illustrates nine eye colors in *Drosophila*, and two other page plates show excellent photomicrographs of both normal and abnormal chromosomal configurations. Diagrams are numerous, but only a few photographs are included. There are problems at the end of each chapter. Probability is discussed in the appendix.

The reviewer gained the impression that the title, "An Introduction to Genetics," is a misnomer, as the book is too technical for the beginning student. Very little is said about human heredity, and the simpler modern statistical techniques, such as chi-square, are not mentioned. The book should be a valuable reference for advanced students in genetics, especially those primarily interested in *Drosophila* and chromosomal phenomena.—*D. C. Rife.*

**An Introduction to Genetics**, by G. W. Beadle and A. H. Sturtevant. xxiii + 391 pp. W. B. Saunders Company, Philadelphia, 1939.

# INDEX

- Alexander, W. H., 187.  
 Anomalous Artery in Kingfisher, 94.  
 Aphids, 57.  
*Argia fumipennis*, 155.  
 Blood of Fishes, 1.  
 Buckeye Lake, 133.  
 Carbon Dioxide Tension, 1.  
 Carlson, F. A., 43.  
*Ceryle alcyon*, 94.  
 Chalcidoidea, 324.  
 Cicadellidae, 110, 235.  
 Coghill, G. E., 239.  
 Coleoptera, 10.  
 Corn, 48, 52.  
 Davidson, R. H., 110.  
 DeLong, D. M., 110, 235.  
 Determinate Evolution, 67.  
*Didelphys virginiana*, 239.  
 Diptera, 52.  
 Dissolved Oxygen, 27.  
 Diurnal Activity Rhythm, 119.  
 Doubling in Frog Embryos, 250.  
 Edwards, L. F., 83.  
 Ellis, R. E., 250.  
 Empoasca, 110.  
 Evolution in Plants, 327.  
 Evolutionary Series, 67.  
 Everly, R. T., 48, 52.  
 Felts, W. M., 297.  
 Fish, 1, 119, 275.  
 Floods, 220.  
 Flora of Ohio, 144.  
 Food of Insects and Spiders, 48, 52.  
 Fresh Water Fishes, 119.  
 Frog, 97, 250.  
 Frog Embryos, 250.  
 Girault, A. A., 324.  
 Glenny, F. H., 94.  
 Gordon Creek, 275.  
 Granodiorite Stock, 297.  
 Grover, F. O., 144.  
 Growth of *Stereum gausapatum*, 254.  
 Hemiptera, 52.  
 Hemoglobin, 1.  
 Herrick, J. A., 254.  
 Histeridae, 10.  
 Hocking River, 259.  
 Hodgman, M. E., 15.  
 Homoptera, 57, 110, 235.  
 Hutchison, L., 259.  
 Hydrogen-ion Concentration, 15.  
 Hymenoptera, 48.  
 Insects in Sweet Corn, 48, 52.  
 Jones, C. H., 232.  
 Kingfisher, 94.  
 Linkage, 291.  
 Lost Creek, 275.  
 Lung of Frog, 97.  
*Macrosiphum solanifolii*, 57.  
 Majestus, 235.  
 Mammals, 133.  
*Moniezia expansa*, 37.  
 Moseley, E. L., 220.  
 Movements of Shoulder-joint, 83.  
 Musculature of Frog, 97.  
 Norris Reservoir, 27.  
 Numerical Status of Mammals, 133.  
 Ohio Academy of Science Meeting, 187.  
 Ohio Flora, 144.  
 Ohio Protozoan Parasites, 157.  
 Ohio River Floods, 220.  
 Ohio Vascular Plants, 232.  
 O'Neal, C. E., 213.  
 Opossum, 239.  
 Orthoptera, 157.  
 Oxygen Demand, 27.  
 Parasites, 157.  
 Penrose, L. S., 291.  
 Powers, E. B., 1.  
 Presidential Address, 213.  
 Protozoan Parasites, 157.  
*Rana pipiens*, 97.  
 Rostorfer, H. H., 1.  
 Rostorfer, T. H., 1.  
 Schaffner, J. H., 67, 232, 327.  
 Semans, F. M., 157.  
 Shoulder-joint, 83.  
 Sib Data, 291.  
 Smith, C. W., 57.  
 Snowfall Maps of Ohio, 43.  
 Spencer, W. P., 119.  
 Spiders, 48, 52.  
 Squire Valleeue Farm, 15.  
*Stereum gausapatum*, 254.  
*Texananus*, 235.  
 Thornton, C. S., 250.  
 Tillite, 000.  
 Trautman, M. B., 275.  
 Varved Slate, 317.  
 Vascular Plants, 232.  
 Violets, 144.  
 Waterman, F. A., 97.  
 Wenzel, R. L., 10.  
 White, G. W., 317.  
 Wiebe, A. H., 27.  
 Williams, S. R., 37.  
 Wright, M., 155.  
 Zoöplankton, 259.



I.A.R.I. 75

INDIAN AGRICULTURAL RESEARCH  
INSTITUTE LIBRARY, NEW DELHI.

Date of Issue	Date of Issue	Date of Issue
12.9.55		
25.1.59		
31.12.58		
3.6.59		
8.6.61		
5.9.64		
14.4.65		